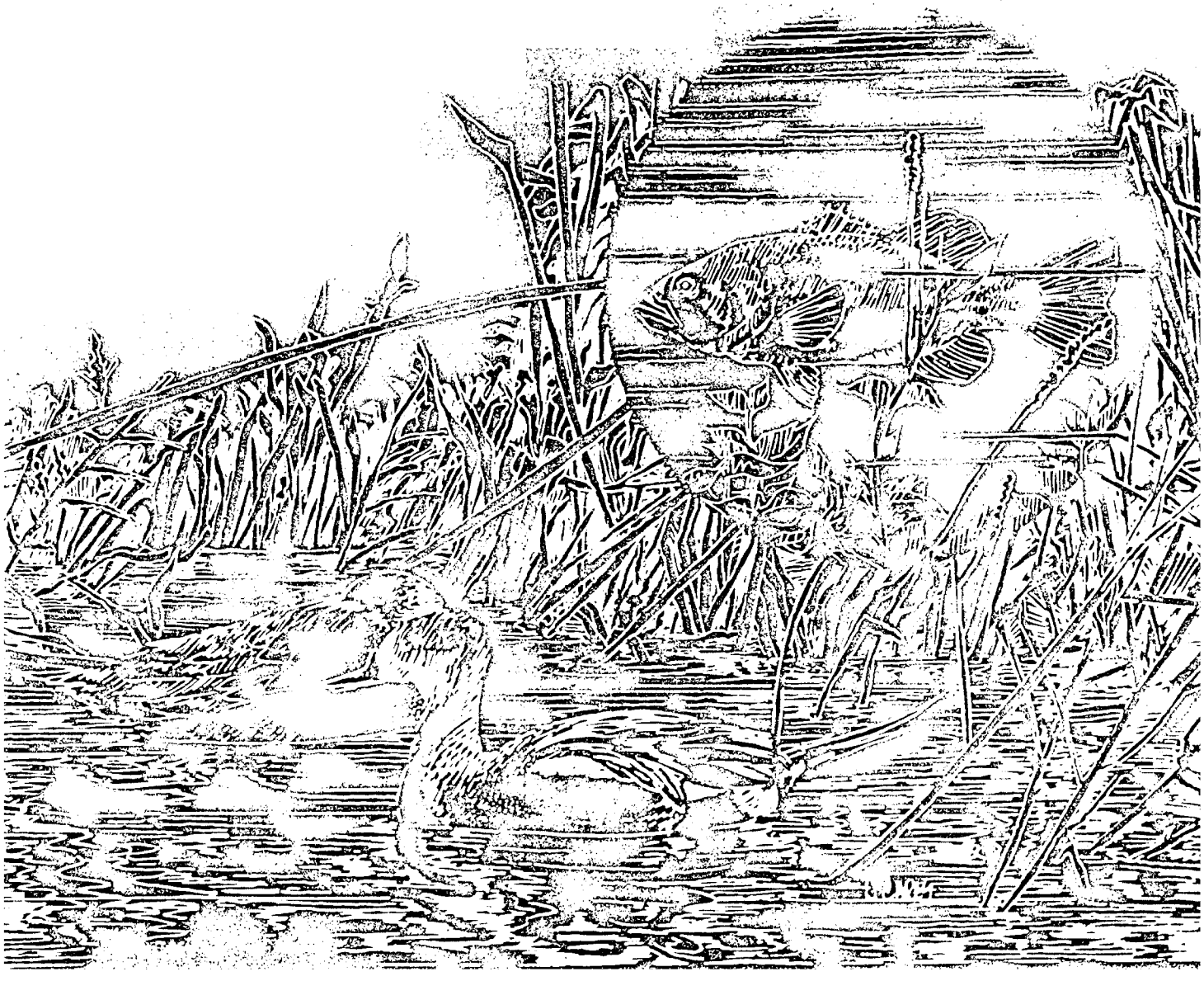
UPPER MISSISSIPPI RIVER SYSTEM ENVIRONMENTAL MANAGEMENT PROGRAM DEFINITE PROJECT REPORT (R-4) WITH INTEGRATED ENVIRONMENTAL ASSESSMENT

ANDALUSIA REFUGE REHABILITATION AND ENHANCEMENT



NOVEMBER 1988

US Army Corps of Engineers
Rock Island District

Pool 16
UPPER MISSISSIPPI RIVER
ROCK ISLAND COUNTY, ILLINOIS

DEPARTMENT OF THE ARMY
ROCK ISLAND DISTRICT, CORPS OF ENGINEERS
CLOCK TOWER BUILDING—P.O. BOX 2004
ROCK ISLAND, ILLINOIS 61204-2004

REPLY TO
ATTENTION OF:

November 15, 1988

Planning Division

SEE REPORT DISTRIBUTION LIST

The Definite Project Report (DPR) with Integrated Environmental Assessment (EA) for the Andalusia Refuge EMP project is enclosed for your review and comment. The Andalusia Refuge project is one of several Habitat Rehabilitation and Enhancement Projects (HREP) in the Upper Mississippi River System - Environmental Management Program (UMRS-EMP).

Purposes of the project are to enhance migratory waterfowl habitat, retard the loss of fish and wildlife aquatic habitat, and increase fish habitat including deep water wintering habitat. Following are the project's major components:

a. Construct a water level control levee approximately 5 feet high, 8,600 feet long, and up to 110 feet wide from toe to toe;

b. Construct a pump station, two water control structures, and an armored lower levee section;

c. Dredge a portion of Dead Slough to approximately 9 feet below flat pool;

d. Dredge the interior of the moist soil management unit (MSMU) formed by the levee to create channels, drainage, and an island;

e. Construct a new mouth for Dead Slough opening into Scisco Chute;

f. Reroute the intermittent stream now emptying into the upper end of the MSMU into Scisco Chute; and

g. Construct an access road to the water control structure and place electrical power supply.

As required by the Clean Water Act, the Section 404(b)(1) Evaluation also is included for comment. Please furnish comments no later than 30 days from the date of this letter. Any questions regarding the EA should be directed to Mr. Robert Clevenstine of our Environmental Analysis Branch at 309/788-6361, Ext. 386. Written comments may be sent to the following address:

District Engineer
U.S. Army Engineer District, Rock Island
ATTN: Planning Division
Clock Tower Building - P.O. Box 2004
Rock Island, Illinois 61204-2004

Sincerely,

Neil A. Smart
Colonel, U.S. Army
District Engineer

Enclosures

DEPARTMENT OF THE ARMY
ROCK ISLAND DISTRICT, CORPS OF ENGINEERS
CLOCK TOWER BUILDING—P.O. BOX 2004
ROCK ISLAND, ILLINOIS 61204-2004

REPLY TO
ATTENTION OF:

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UPPER MISSISSIPPI RIVER SYSTEM
ENVIRONMENTAL MANAGEMENT PROGRAM
DEFINITE PROJECT REPORT
WITH INTEGRATED ENVIRONMENTAL ASSESSMENT

ANDALUSIA REFUGE
REHABILITATION AND ENHANCEMENT

POOL 16, MISSISSIPPI RIVER MILES 462 THROUGH 463

ROCK ISLAND COUNTY, ILLINOIS

NOVEMBER 1988

ACKNOWLEDGMENT

Primary study team personnel who are familiar with the technical aspects of the study are listed below:

PROJECT MANAGER: Andrew J. Bruzewicz

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WATER QUALITY: Clint Beckert, Ph.D

EXECUTIVE SUMMARY

Andalusia Refuge and adjacent Dead Slough, located in Pool 16, are a 393-acre backwater complex approximately 1 mile north of Illinois City, Illinois. The proposed site is closed to hunting and located within the Upper Mississippi River Wildlife and Fish Refuge on General Plan lands made available to Illinois through cooperative agreements between the Corps of Engineers and the Department of Interior, and between the Department of Interior and the State. The refuge is managed by the Illinois Department of Conservation in accordance with an annual program submitted to the U.S. Fish and Wildlife Service as a National Wildlife Refuge within the meaning of Section 906(e) of the 1986 Water Resources Development Act.

Sedimentation from the Mississippi River and adjacent uplands has significantly impacted on the Andalusia Refuge and adjacent backwater fisheries. Migratory waterfowl already under stress due to drought conditions and loss of habitat in the Upper Midwest have been affected, and necessary deep water fish habitat off the main channel has been reduced. Duck counts by the Illinois Department of Conservation show that the duck use days at the Refuge, an important link for waterfowl using the Mississippi flyway, are exceedingly low. Food may be present in the Refuge, but there is often no available water. Present peak waterfowl use days are less than 2,000. This compares to conditions at the next nearest refuges, where water levels can be controlled, at Lake Odessa (River Mile 437) and Princeton Refuge (River Mile 507). Peak use days at these refuges are as much as 50 times higher than Andalusia Refuge. Additionally, fish are trapped in adjacent sloughs when water levels fall in the late spring and die from low levels of dissolved oxygen, and, in some years, from the high summer water temperatures or winter freeze-outs caused by the almost complete absence of water.

Alternative locations in the floodplain between Lake Odessa and Princeton Refuge were considered. Pool 17 has very little potential for sites in the upper pool due to flood control levees close to each shoreline. The first suitable location is already occupied by the Big Timber Division of the Mark Twain National Wildlife Refuge (River Mile 444). In Pool 16, Andalusia Island (River Mile 467) is not feasible because of the absence of land access and significantly higher construction costs necessitated by having to levee the entire perimeter. "Milan Bottoms" (River Mile 477) is not feasible since land dedicated to new uses would involve significant loss of present wood duck and terrestrial habitat benefits. There are no suitable locations in Pool 15 due to intense development, and none in Pool 14 below the existing refuge at Princeton, Iowa.

Project objectives are to: enhance migratory waterfowl habitat by providing adequate vegetation and reliable loafing and resting areas; retard the loss of fish and wildlife aquatic habitat by reducing sedimentation into the Refuge and Dead Slough; increase fish habitat in Dead Slough by channel excavation; and increase habitat available for wintering fish by providing deeper water areas.

The alternatives considered to accomplish the objectives included: variously sized moist soil management units (MSMU's); diversion of four adjacent watersheds supplying flow and sediment; river bank protection of the Refuge; various access channels and slough excavation configurations for Dead Slough; varying interior and side channel drainage excavation and associated island configurations within the MSMU; and various access road configurations to permit pump station and levee maintenance access. MSMU sizes considered ranged from a 130-acre area protected by a perimeter 2-year earthen levee approximately 6 feet high with a 12-foot crown to a 265-acre MSMU protected by levees corresponding to 5- and 10-year events with average heights of 9 and 11 feet, respectively. Watershed diversions considered all four watersheds and included diversion drainage lengths of 2,200 to 2,500 feet on private land which would require permanent easements or additional fee title. River bank protection would consist of crushed stone bedding with a riprap blanket to protect approximately 85 acres of emergent and submergent vegetation from possible Mississippi River erosion.

Dead Slough and access channel alternatives required locations where neither erosion nor deposition occurred and which were consistent with other project features, while allowing adequate material placement. Interior channels were necessary to facilitate drainage during drawdowns, hastening establishment of new vegetation, and to provide material for adjacent levee borrow. Interior material placement had to provide optimal island protection for waterfowl from foraging land animals. Access to the pump station alternatives required reliable all-year access, consideration of potential disruption of Refuge objectives due to unauthorized access, and clearing and ownership considerations.

The selected plan for the habitat project consists of constructing a 2-year event levee averaging approximately 6 feet high, 8,600 feet long with top widths of either 12 feet or 60 feet, providing water level control on 130 acres of Refuge land. Included are a pump station capable of pumping 3,500 gallons per minute into the Refuge and 5,000 gallons per minute from the Refuge, one gated water control structure, and an armored lower section of the levee to withstand overtopping of the levee without damage during floods. Mechanical excavation in Dead Slough to a depth approximately 9 feet below flat pool (about 110,000 cubic yards) and in the interior of the MSMU (about 75,000 cubic yards) will create approximately 3.1 miles of channel (10,900 feet within the MSMU and 5,600 feet within Dead Slough). Channel width within Dead Slough adjacent to the levee will be 60 feet at the base of the cut. The configuration of the dredged channel within the MSMU will create eight or more islands, totalling about 9 acres. These channels will enable fish to leave the MSMU through a water control structure into Dead Slough and then into the main channel. The new mouth of Dead Slough will empty into Scisco Chute. The intermittent stream now depositing sediment in Refuge backwaters will be redirected to Scisco Chute, decreasing the sedimentation rate in the Refuge and Dead Slough. The new channel will be 2,430 feet long and 3 feet deep with a 30-foot bottom width. It will be located on Government-owned land and will be capable of conveying a 2-year event within bank. The other three streams have no feasible rerouting alternatives and will be left unchanged. River bank erosion was determined to be insignificant, not threatening the stability of the bank or the interior portion of the Refuge. The recommended

access road consists of approximately 3,600 feet of a 12-foot-wide service road, which also will be used for placement of overhead poles for electric power supply. Illinois Department of Conservation personnel will control access to the road to minimize disturbance to the Refuge area.

Average annual operation and maintenance costs of the project are estimated to be $11,400. The Illinois Department of Conservation has agreed to be responsible for the operation and maintenance of the project.

The habitat project will create a reliable food supply for migratory waterfowl in the fall, enabling water level manipulation on 130 acres of wetland to enhance food production. With the ability to manage water levels, water usually would be drawn down in June for the germination of natural or aerially seeded plants benefitting waterfowl, such as smartweed or Japanese millet. Water levels would be raised as the plants grow, allowing the seed heads to remain above the water level. The levee will prevent 2-year flood events (which have occurred only twice during the 22 years of record for the management period) from destroying the food crop, significantly increasing the Refuge's capacity to provide food and refuge. The channel configuration within the MSMU will create 9 acres of island suitable for the nesting of Canada geese. Improvements within Dead Slough and reopening the access will provide improved water circulation, increased levels of dissolved oxygen, and a decrease in the rapid water temperature fluctuations which now occur. The relocated drainage channel will improve water quality in Dead Slough and in the MSMU, with the decreased sediment influx prolonging project life.

It is proposed that the following information be collected to evaluate performance of the project: summer and winter measurement of dissolved oxygen in Dead Slough; soundings of Dead Slough and fish access channel excavations; sedimentation measurements within the MSMU; biennial waterfowl inventories during the fall migration; biennial vegetation inventories by water level and by time of year within the MSMU; and, biennial fishery inventories in Dead Slough.

The District Engineer has reviewed the project outputs and determined that implementation of the identified plan is justified and in the Federal interest. The project area is managed as a National Wildlife Refuge within the meaning of Section 906(e) of the 1986 Water Resources Development Act. Therefore, approval for construction of the Andalusia Refuge habitat rehabilitation and enhancement project is recommended by the Rock Island District Engineer at a 100 percent Federal cost estimated to total $1,870,000. The District Engineer further recommends that funds in the amount of $24,000 be allocated as quickly as possible for the preparation of plans and specifications.

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ENVIRONMENTAL MANAGEMENT PROGRAM
DEFINITE PROJECT REPORT
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ANDALUSIA REFUGE
REHABILITATION AND ENHANCEMENT

POOL 16, MISSISSIPPI RIVER MILES 462 THROUGH 463

ROCK ISLAND COUNTY, ILLINOIS

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POOL 16, MISSISSIPPI RIVER MILES 462 THROUGH 463

ROCK ISLAND COUNTY, ILLINOIS

1. INTRODUCTION.

a. Purpose. The purpose of this report is to present a detailed proposal for the rehabilitation and enhancement of Andalusia Refuge. This report provides planning, engineering, and sufficient construction details of the selected plan to allow final design and construction to proceed subsequent to approval of this document.

b. Resource Problems and Opportunities. Andalusia Refuge and adjacent Dead Slough is a 393-acre backwater complex located between Mississippi River miles 462 and 463 in Pool 16. The project, located in Rock Island County, Illinois, lies on the Illinois left bank of the Mississippi River across from Fairport, Iowa, and is also about 1 mile north of Illinois City, Illinois. The proposed project is located within the Upper Mississippi River Wildlife and Fish Refuge on General Plan lands owned by the U.S. Army Corps of Engineers. The site is managed by the Illinois Department of Conservation (IDOC) under authority of Cooperative Agreements with the U.S. Fish and Wildlife Service (USFWS) and the Corps of Engineers.

The IDOC manages the approximately 393-acre Refuge primarily as a feeding and resting area for waterfowl. At present, there is no water level control in the Refuge, which limits management capability in providing quality habitat for waterfowl. The portion of the Refuge south of Dead Slough is particularly shallow and frequently has little or no water during the fall waterfowl migration. Although waterfowl food, such as smartweed and arrowhead, is often present, the lack of water level control significantly decreases the Refuge's ability to support migratory waterfowl, which is its primary objective.

In addition, sediment originates from both the Mississippi River during flood events and adjacent watersheds. Sediment from the adjacent bluff-top watersheds enters the Refuge through several small streams that empty into the upper end of the Refuge. Sediments decrease the water volume in the Refuge. This sedimentation has caused a succession from a dominance of aquatic bed-palustrine wetlands to more emergent class plant species such as sedge, rice-cutgrass, and willow. Acquisition of water level control and channel dredging can compensate for this sedimentation and reserve the plant succession from terrestrial toward a more desirable aquatic and semi-aquatic (marsh) condition.

Measures to prevent sediment deposition from adjacent upland erosion include upland erosion control and/or diversion of adjacent watershed flows having heavy sediment loads from the project site. The principal measures to reduce river source sediment are diverting river flows or blocking flows through the area. Such measures would include use of natural tree buffers, construction of levee systems, or construction of deflection dikes.

The proposed project will fill an important gap in providing a reliable and much needed refuge for fall migratory waterfowl along the Upper Mississippi River. Between the Iowa Department of Natural Resources (DNR) Refuges at Princeton, Iowa (River Mile 507) and Lake Odessa, Iowa (River Mile 437), there are no other waterfowl refuges capable of water level control. Water level control is a necessary management tool for river refuges in order to provide a reliable food source for fall migrating waterfowl. Although natural waterfowl food sources (i.e., smartweed, arrowhead, wild celery, wild millet) are occasionally abundant when low summertime water levels occur, fall high water events frequently ruin their value to waterfowl. The construction of a Moist Soil Management Unit (MSMU) on the Andalusia Refuge (River Mile 462) will allow: (1) the reliable production of waterfowl food crops during summer months and (2) protection from loss due to fall flood events and optimization of water levels for waterfowl.

Construction of the levee required for the MSMU is also a unique opportunity to restore a backwater fishery habitat in Dead Slough that has been gradually lost due to sedimentation. The Andalusia Refuge overall has experienced sedimentation at an average rate of 0.5 inch/year since construction of the 9-foot channel. Dead Slough itself has experienced a rate closer to 0.8 inch/year due to pre-lock and dam deeper areas. Dead Slough is a backwater pond which is now isolated from the main river due to sedimentation at its mouth. Falling water levels regularly trap fish in the slough and cause frequent fish kills when dissolved oxygen is depleted. The reconnection of Dead Slough to the main river will restore and enhance the fishery resources of that portion of the Refuge.

c. Scope of Study. The geographical scope of the study area is shown on plates 1 and 2. Emphasis was placed on developing project features which were located on existing State or Federal lands. Although additional land could be purchased by non-Federal interests, alternatives with land acquisition were generally not pursued due to policy, scheduling, and funding purposes. Alternatives involving upland erosion control were not studied in detail. The U.S. Soil Conservation Service has primary jurisdiction for these programs.

Field surveys were performed in developing sedimentation estimates, assessing effects near project boundaries and Government property lines, and estimating excavation/dredge quantities. Surveyed sections will be used to evaluate post-construction performance.

Soil borings were taken to assess sediment types, to verify foundations of proposed structures, and to determine excavation/dredging difficulty. Water quality sampling was initiated at the commencement of the study and will continue through construction.

Fish and waterfowl observations within the study area were made by the IDOC. These observations will assist in evaluating project performance.

d. Format of Report. The report is organized to follow a general problem solving format. The purpose and problems are presented in Section 1. Section 2 provides an overview of how and why Andalusia Refuge was selected as a project within the Environmental Management Program. Section 3 establishes the baseline for existing resources. Section 4 provides the objectives of the project. Sections 5 and 6 propose and evaluate project alternatives. Sections 7 and 8 describe the selected plan. Section 9 is an assessment of environmental effects from the proposed plan. Section 10 provides a summary of project accomplishments or benefits. Sections 11, 12, and 13 describe estimated operation and maintenance considerations, performance monitoring, and detailed cost estimates for both initial construction and annual operation and maintenance. Sections 14, 15, 16, and 17 provide a summary of implementation requirements and coordination. Sections 18, 19, and 20 present the conclusions, recommendations, and Finding of No Significant Impact.

Drawings (plates) have been furnished to provide sufficient detail to allow review of the existing features and the proposed plan. Plates 1, 2, and 3 show the project location, the recommended plan, and alternative plans. Plate 4 shows adjacent watersheds which were studied to evaluate adjacent sedimentation effects. Plates 5 and 6 provide 22 years of hydrographic record of the Mississippi River at the proposed project site. These hydrographs provide the relationship between river flood events and proposed levee heights. Plate 7 provides soil borings which were used to evaluate foundation effects and excavation/fill methods. Plates 8, 9, 10, 11, 12, and 14 provide plan views of the selected alternative. Plate 13 was included to show existing ground surfaces relative to river erosion effects. This plate, with accompanying monitoring plates of 23, 24, and 25, provides a basis for future monitoring ranges. Plates 15, 16, 17, 18, and 19 provide profiles and section views for the selected plan. Plates 20, 21, and 22 provide concept plans and details for the pump station and the water control plan.

e. Authority. The authority for this report is provided by the 1985 Supplemental Appropriations Act (Public Law 99-88) and Section 1103 of the Water Resources Development Act of 1986 (Public Law 99-662). The proposed project would be funded and constructed under this authorization. Section 1103 is summarized as follows:

> Section 1103. UPPER MISSISSIPPI RIVER PLAN
>
> (a) (1) This section may be cited as the Upper Mississippi River Management Act of 1986.
>
> (2) To ensure the coordinated development and enhancement of the Upper Mississippi River System (UMR), it is hereby declared to be the intent of Congress to recognize that system as a nationally significant ecosystem and a nationally significant commercial navigation system. Congress further recognizes

that this system provides a diversity of opportunities and experiences. The system shall be administered and regulated in recognition of its several purposes.

(e) (1) The Secretary, in consultation with the Secretary of the Interior and the States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin, is authorized to undertake, as identified in the Master Plan -

(A) a program for the planning, construction, and evaluation of measures for fish and wildlife habitat rehabilitation and enhancement...

2. GENERAL PROJECT SELECTION PROCESS.

a. Eligibility Criteria. A design memorandum (or implementation document) did not exist at the time of the enactment of Section 1103 of the Water Resources Development Act of 1986. Therefore, the North Central Division, U.S. Army Corps of Engineers, completed a "General Plan" for implementation of the Upper Mississippi River System-Environmental Management Program (UMRS-EMP) in January 1986. The USFWS, Region 3, and the five affected States (Illinois, Iowa, Minnesota, Missouri, and Wisconsin) participated through the Upper Mississippi River Basin Association (UMRBA). Programmatic updates of the General Plan for budget planning and policy development are accomplished through Annual Addendums.

Coordination with the States and the USFWS during the preparation of the General Plan and Annual Addendums led to an examination of the Comprehensive Master Plan for the Management of the Upper Mississippi River System. The Master Plan, completed by the Upper Mississippi River Basin Commission in 1981, was the basis of the recommendations enacted into law in Section 1103. The Master Plan report and the General Plan identified examples of potential habitat rehabilitation and enhancement techniques. Consideration of the Federal interest and Federal policies has resulted in the following conclusions:

(1) First Annual Addendum. The Master Plan report... and the authorizing legislation do not pose explicit constraints on the kinds of projects to be implemented under the UMRS-EMP. For habitat projects, the main eligibility criteria should be that a direct relationship should exist between the project and the central problem as defined by the Master Plan, i.e., the sedimentation of backwaters and side channels of the UMRS. Other criteria include geographic proximity to the river (for erosion control), other agency missions, and whether the condition is the result of deferred maintenance....

(2) Second Annual Addendum. The types of projects that are definitely within the realm of Corps of Engineers implementation authorities include the following:

- backwater dredging
- dike and levee construction
- island construction
- bank stabilization
- side channel openings/closures
- wing and closing dam modifications
- aeration and water control systems
- waterfowl nesting cover (as a complement to one of the other project types)
- acquisition of wildlife lands (for wetland restoration and protection.) Note: By letter of 5 February 1988, the Office of the Chief of Engineers directed that such projects not be pursued.

A number of innovative structural and nonstructural solutions which address human-induced impacts, particularly those related to navigation traffic and operation and maintenance of the navigation system, could result in significant long-term protection of UMRS habitat. Therefore, proposed projects which include such measures will not be categorically excluded from consideration, but the policy and technical feasibility of each of these measures will be investigated on a case-by-case basis and recommended only after consideration of system-wide effects.

b. Selection Process. Projects are nominated for inclusion in the Rock Island District's habitat projects program by the respective State conservation agencies and the USFWS based on agency management objectives. To assist in the project formulation process, the Fish and Wildlife Interagency Committee (FWIC), a group composed of State and Federal biologists who work at projects along the Mississippi River and Illinois Waterway, convened a series of meetings in 1986 to consider critical habitat needs along the Mississippi River. At these meetings, the available habitat was evaluated on a pool-by-pool basis. This analysis revealed deficiencies (such as feeding, resting, and loafing areas for migratory waterfowl, absence of deep water off the main channel for diving ducks, fish, etc.) as well as types of habitat in abundant supply (e.g., mature bottomland hardwood). With this information, projects being considered can most accurately reflect broader regional needs in addition to representing the best site-specific choices.

Rock Island District assists the State and the USFWS agencies proposing habitat projects through use of an in-house task force with members from the design, hydraulics, channel maintenance, environmental, and waterways planning branches. As projects are being conceptualized, this groups meets on-site with State and USFWS personnel to examine as fully as possible what site-specific benefits would be both desirable and engineeringly feasible.

As input to the District to assist in the final selection of projects to be included in the program, projects are ranked according to the biological benefits that they could provide by the FWIC. Each project is considered, and

project alternatives to increase habitat benefits for fish, waterfowl, and other wildlife are suggested. Every project is ranked according to the benefits provided as high, medium, or low.

The FWIC rankings are forwarded to the District and to the River Resources Coordinating Team (RRCT), an interagency policy group which meets to coordinate Mississippi River activities. The RRCT examines the FWIC rankings and includes consideration of the broader policy perspectives of the agencies submitting the projects. The RRCT-recommended rankings also are submitted to the District, and the District then formulates and submits a recommended program to the EMP program manager at North Central Division which is consistent with the overall program objectives.

Projects consequently have been screened by biologists closely acquainted with the rivers. Resource needs and deficiencies have been considered on a pool-by-pool basis to ensure that regional needs are being met and that the best expertise available is being used to optimize the habitat benefits created at the most suitable locations.

c. Specific Site Selection. Through the above selection process, Andalusia Refuge was recommended and supported as capable of providing high waterfowl and aquatic benefits if proposed project features were implemented. The site is located on existing federally owned lands, a significant aspect relative to project development. Andalusia Refuge is also locally known by the public as a closed refuge, minimizing land use changes and potential adverse public reactions.

Other floodplain and out-of-floodplain locations were evaluated within this reach of the river for potential waterfowl and aquatic enhancement benefits. Out-of-floodplain or upland (non-wetland) locations were considered not feasible for this project. The very nature of waterfowl and aquatic enhancement is wetland dependent and requires that it be constructed in a location with an abundant surface water supply immediately adjacent to the river.

Alternate locations to the Andalusia Refuge site (River Mile 462) within the floodplain were considered. In Pool 16, there are only two other locations where similar waterfowl water control measures could possibly be located: Andalusia Island and the "Milan Bottoms" near the mouth of the Rock River.

The Andalusia Island complex (River Mile 467) is very similar to the proposed project site. Its location being an island, however, would make management extremely difficult due to the lack of land access. Construction costs also would be significantly higher because a levee would be required on all four sides.

The "Milan Bottoms" area is a large, several-hundred-acre forest-wetland complex (River Mile 477) that State biologists in the past have considered as having potential for waterfowl habitat development. This area has some of the best existing habitat in Pools 15 and 16 because of its diverse complex of wetlands, backwaters, and forest. The area already is extremely important reproductive habitat for wood ducks. But it would be difficult to achieve

enough migratory habitat benefits to overcome the potential loss of reproductive habitat. Negative impacts to other wildlife increase the losses. The lack of a large, unforested expanse would require extensive clearing to achieve waterfowl benefits similar to those at the currently proposed location.

Pool 15 offers no possible locations due to its intensely developed nature, and Pool 14 offers no suitable locations until the existing refuge at Princeton, Iowa, (River Mile 507). Downstream, Pool 17 has very little potential for sites in the upper part because of flood control levees close to each shoreline. The first suitable location is already occupied by the Lake Odessa, Iowa, Refuge (River Mile 437). The lack of suitable alternative sites emphasizes the importance of developing the existing Andalusia Refuge.

3. ASSESSMENT OF EXISTING RESOURCES.

a. Resource History. The Refuge area was principally a wooded area prior to the completion of Lock and Dam 16 at Muscatine, Iowa, in 1937. The present Dead Slough area was considered a lake in 1936, but once Pool 16 was formed, the area became as series of backwater channels, ponds, and lakes.

The U.S. Army Corps of Engineers acquired the acreage of the project site for navigational purposes prior to completion of the lock and dam. These lands are presently managed as part of the Upper Mississippi River Wildlife and Fish Refuge under terms of a Cooperative Agreement dated February 14, 1963, between the Department of the Army and the Department of Interior, and a subsequent Agreement between the Department of Interior and the IDOC.

b. Land Use. The Andalusia Waterfowl Refuge is managed by the IDOC. It is closed to all hunting from October 1 through December 31 every year in order to provide a feeding and resting area for migratory waterfowl. The Refuge (between River Miles 462-463) and surrounding habitat total approximately 393 acres. Based on aerial photographs taken in September 1984 and a 1982 IDOC vegetation survey, the composition of the Refuge as presented in table 3-1.

The upper end of the Refuge has the highest elevation. This area receives a significant amount of sediment deposition from the small creek which is proposed for realignment and is now completely dominated by wet soil species such as sedge and rice cutgrass. Proceeding westward (downstream), the vegetation gradually changes toward more aquatic species such as arrowhead and bulrush, and eventually to submerged species such as coontail, pondweed, and star grass in deeper areas. Dead Slough has no deep, open water and is 100 percent composed of submergents such as coontail, curlyleaf pondweed, duckweed, and potamogeton. The mouth of Dead Slough is a vegetated mudflat dominated by willow and giant smartweed.

In contrast to the existing conditions, 1964 aerial photographs showed a refuge consisting predominantly of open water and woodland. Sedimentation was evident at the mouth of Dead Slough, but a channel was still contiguous with the main river at low water. At present, Dead Slough has no water exchange

with the river except during floods. Several of the small, shallow backwater ponds and inlets within the Refuge have since succeeded to vegetated mudflats, willow thickets, or other persistent emergent wetland types.

TABLE 3-1

Andalusia Refuge Existing Features

Aquatic Conditions	Area, Acres
Main Channel	-
Main Channel Border	-
Side Channel	-
Sloughs	-
River Lake, Floating Submergent (lotus, coontail, duckweed)	87.0
Open Water (Occasional)	7.5
Total Aquatic	94.5
Terrestrial/Wetland Conditions	
Forest (silver maple, cottonwood, willow)	236.0
Brush	-
Meadow	-
Sand	-
Mudflat, Emergent Persistent and Non-Persistent (rice cutgrass, arrowhead, smartweed, bulrush, cattail)	62.0
Agriculture	-
Developed	-
Total Terrestrial	298.0
Total Aquatic and Terrestrial	392.5

c. Existing Fisheries Use. Dead Slough is an extremely shallow backwater slough of the Mississippi River. Maximum depth at an adjusted flat pool stage of 545.0 MSL (Fairport gauge) was approximately 1.5 feet in May of 1988 compared to the Plane Table survey of 1936 which showed mean depths of 6 feet from the same reference stage. The slough is virtually 100 percent vegetated during summer growing periods, with coontail, curlyleaf pondweed, and duckweed dominating the vegetation.

Fish populations in the slough are sporadic and stage-dependent. Severe summer and winter kills have been reported by both local residents and IDOC district wildlife biologists. These kills have been attributed to dissolved oxygen crashes brought on by high sediment oxygen demands and biological oxygen demands coupled with thermal stresses. The slough undoubtedly acts

as an important fish refuge area during flood events and provides sport fishing opportunities during these periods. The slough also provides spawning and/or nursery habitat for fish species including carp, largemouth bass, black crappie, bluegill, smallmouth buffalo, and golden shiners. Other species collected in the area during a May 1988 sampling were shortnose gar, bowfin, gizzard shad, and central mudminnow. Fish trapped in the area by receding water are subjected to extreme dissolved oxygen and temperature stress, often leading to the fish kills already discussed. Because of these conditions, the net fisheries value of this area is near zero or is negative. During spring and fall floods, the area has value, but this value is largely negated by subsequent fish kills.

d. Existing Waterfowl Use. Migratory waterfowl use of Andalusia Refuge is low, primarily due to its erratic food production for migratory waterfowl. The Refuge's present primary benefit is in providing a resting area (no hunting). Available food, such as duck potato, wild millet, and smartweed, varies annually according to water level fluctuations. Summer floods often prevent germination or growth of food plants, or late fall flood events often inundate good food crops under several feet of water. Active management of the Refuge is minimal since there is very little that can be done to significantly affect habitat quality for waterfowl. Censuses of waterfowl use in the Refuge indicate very low use compared to other waterfowl refuges in nearby pools that have water level management capability.

The aerial census information available for the Andalusia Refuge indicates that peak waterfowl use days probably has never exceeded 2,000. This is no better than other unmanaged locations in Pool 16. In comparison, the 348-acre refuge at Princeton, Iowa (Pool 14) had 100,000 duck use days for the 1987 fall migration and a peak day use of 15,000. Figures for other years are comparable.

e. Water Quality. The water quality of Dead Slough is poor. The shallow depth (maximum of 1.5 feet at flat pool) and lack of contiguity with the main river cause frequent oxygen depletion and increased temperature in summer and fall. Total fish kills are common following high water periods that leave fish stranded in the slough without any exit.

There is very little to no water in the refuge area proposed for levee protection. Most of the area consists of moist soil vegetation (reed canary grass, sedge, cattail, etc.) with water present only during spring and fall flooding.

Elutriate analyses showed only ammonia-nitrogen exceeding surface water quality standards. The effects of ammonia-nitrogen can be minimized by selecting appropriate construction methods and/or excavation/dredging during low temperature and pH seasons of the year.

f. Endangered Species. The following federally endangered species are listed as being historically or currently present in Rock Island County:

Indiana bat	Myotis sodalis
Bald eagle	Haliaeetus leucocephalus
Higgins' eye pearly mussel	Lampsilis higginsi
Fat pocketbook	Potamilus capax

None of these species has been observed or documented on the project, except for periodic use by bald eagles during late fall and early winter.

g. Cultural Resources. The proposed project levee alignment will impact a natural levee. Both the proposed stream diversion channel and access road crosscut alluvial fans. Previous investigations in the Mississippi River floodplain indicate that natural levees have a moderate potential for containing archeological deposits, while alluvial fans have been found to have much higher potential for containing intact buried archeological deposits. Previous archeological surveys conducted in the Mississippi River Pool 16 area have documented archeological sites dating from the Archaic period, 8,000 years ago, to the Woodland period, 900 years ago. None of the proposed project area had been previously examined for historic properties.

h. Adjacent Water Projects. The proposed Andalusia Refuge project is adjacent to the Mississippi River 9-Foot Channel, as authorized by the Rivers and Harbors Act of July 3, 1930. Proposed project features of this report will not affect navigation.

i. Sedimentation. A sedimentation study was conducted to evaluate sedimentation in Dead Slough and in the Refuge area during the period 1936 through 1987. The average sedimentation rate for the entire area has been 0.5 inch/year. The average rate for Dead Slough has been approximately 0.8 inch/year.

The two predominant sedimentation sources are the Mississippi River and adjacent upland erosion. A comparison of river versus upland erosion is presented in table 3-2, along with potential sediment reductions due to the proposed project.

4. PROJECT OBJECTIVES. The objectives of the project are to:

a. Enhance migratory waterfowl habitat by providing adequate vegetation in reliable resting and loafing areas.

b. Retard the loss of fish and wildlife aquatic habitat by reducing sedimentation into the Refuge and Dead Slough.

c. Increase fish habitat in Dead Slough by access and channel excavation.

d. Increase habitat available for wintering fish by providing deeper water areas.

TABLE 3-2

Comparison of River Versus Upland Erosion Sedimentation

Sedimentation Source	Existing Conditions		Sedimentation Reduction Due to Proposed Project	
	Ac-Ft/Yr	%	Ac-Ft/Yr	%
Adjacent Watershed	11.0	39.3	4.2	15.0 a/
River	17.0	60.7	0.0	0.0
Net	28.0	100.0	4.2	15.0

a/ $(28.0 - 4.2) \div 28.0 = .15$

5. ALTERNATIVES.

a. Alternative A - No Federal Action. No Federal action would consist of no Federal funds being provided to meet the project purposes. State and local funds would be required to restore and enhance aquatic habitat.

b. Alternative B - 130-Acre MSMU Protected by 2-Year Levee. This plan consists of the construction of an approximate 130-acre MSMU protected by a perimeter 2-year earthen levee. The unit would consist of a perimeter levee approximately 8,600 feet in length tying into adjacent high ground on the south, as shown on plate 2. The MSMU area would be supported by a permanent pump station and water control structure. The pump station would have the capability of pumping from the MSMU during dewatering to the Mississippi River and also would be able to pump from the Mississippi River to the MSMU for additional inundation during migratory periods.

The general operating scenario for this alternative would consist of dewatering the unit commencing in June of each year (or as soon as possible following spring floods) and maintaining a dewatered condition through July and August. During this dewatered time, natural vegetation would emerge and/or seeds would be planted which would best support migrating waterfowl. Once either planted seeds or natural vegetation occurs, water levels would be allowed to increase within the unit by gravity flow. After water levels and vegetation within the unit reach adjacent river levels, additional water would be pumped from the river into the unit during September and October. The pumping of additional water would utilize the full capacity of the MSMU for migratory waterfowl.

The 2-year event levee would be approximately 6 feet high with a minimum 12-foot crown and typical sections as shown on plates 18 and 19. Because this is only a 2-year event levee, provisions are necessary to allow overflow to occur without significant annual maintenance.

Overflow of the levee would occur by means of a riprap-protected section, as shown on plate 12, and by use of the gates on both the water control structure and the pump station.

c. Alternative C - Other MSMU Sizes. Additional sizes of MSMU's within the study area also were considered, as shown on plate 3. An additional 90 acres of unit could be achieved by extending the levee system down river by about 3,000 feet, as shown.

Approximately 65 additional acres also could be added by extending the perimeter system around Dead Slough, as shown on plate 3. Water levels within Dead Slough and the Refuge would be controlled by a similar pump station and water control structure, as discussed in Alternative B.

d. Alternative D - MSMU Protected by Higher Levees. Higher levees to protect the MSMU also were studied, and levee heights corresponding to 5- and 10-year event frequencies were evaluated. These levees would consist of the same features as described in Alternative B, but would have approximate average levee heights of 9 feet and 11 feet for the 5- and 10-year events, respectively.

e. Alternative E - Adjacent Watershed Flow and Sediment Diversion. Adjacent watersheds with corresponding tributary drainage areas are shown on plate 4. Sediment from watersheds A, B, and C enters the project site with no practical alternative for diversion. Sediment from watershed D enters the project site and may be diverted.

Proposed diversion of sediment from watershed D consists of the construction of a diversion drainage ditch, as shown on plate 3. The diversion ditch is located on Government property and adequately intercepts all flows from this watershed and diverts them directly to Scisco Chute. The diversion ditch consists of a trapezoidal-shaped excavated channel approximately 30 feet wide at the bottom and approximately 2,430 feet long.

An alternative location for the diversion drainage ditch would consist of a ditch located as shown on plate 3. This ditch would require a permanent easement or fee title to lands off Government property. This alternative location would consist of the same typical section and would be approximately 2,200 feet long.

f. Alternative F - Refuge Bank Protection. River bank protection from Mississippi River flood events also was studied, as shown on plate 3. This protection would consist of 6 inches of crushed stone bedding with an 18-inch riprap blanket approximately 2,600 feet long. The intended purpose of this bank stabilization is to protect approximately 85 acres of emergent and submergent vegetation, as shown, from possible Mississippi River erosion.

g. Alternative G - Dead Slough Aquatic Improvement. This alternative consists of excavating an access channel to Dead Slough and adjacent channel excavation to the levee for improved habitat volume and quality. The improved areas should be deep enough to allow fish to winter and also to allow for future Dead Slough sedimentation. Various configurations of access and slough

excavation were considered, as shown on plate 3. The mouth of the new access channel should be located in a zone which neither erodes nor exhibits sedimentation. Excavation within Dead Slough should be compatible with other project features to allow adequate material placement. The estimated length of the Dead Slough aquatic improvement is 5,600 feet.

h. Alternative H - Refuge Drainage/Island Construction. This alternative consists of the construction of interior and side channel drainage channels with associated islands, as shown on plate 2. Interior drainage channels approximately 8,600 feet long and 50 feet wide would facilitate drainage during pump station drawdowns and hasten establishment of new vegetation. Material excavated from the interior drainage channels would be placed to construct about 9 acres of islands which would serve as island refuge to waterfowl from land-based foraging animals.

The interior side channel would be constructed for adjacent levee borrow purposes, would assist in interior drainage during drawdown, and would provide a pool for aquatic habitat during the drawdown period. The total length of this channel would be approximately 2,300 feet, with a 20-foot bottom width. A portion of this channel, 600 feet in length, would be about 6 feet deep during drawdown.

6. EVALUATION OF ALTERNATIVES.

Alternative A, No Federal Action, would not meet project objectives of enhancing migratory waterfowl by providing resting/food support areas or improving or stabilizing aquatic habitat from further sedimentation degradation. Fish kills would continue to occur in Dead Slough when water levels fall, trapping fish without egress to the river. Benefits to waterfowl would continue to fluctuate erratically, depending upon the season and frequency of flood events. Even this marginal waterfowl habitat would gradually decrease as aquatic habitat succeeds toward a more terrestrial cover type. Up to 14 acres of bottomland hardwood would be saved directly if the levee and relocated drainage channel were not constructed. Approximately 18 acres of emergent/submergent wetland would not be converted to deep aquatic habitat. The leveed area would remain contiguous to the main river with no levee to affect fish movement into flooded vegetation.

Alternative B, 130-Acre MSMU Protected by a 2-Year Levee, is compatible with existing Government lands and provides other aquatic improvement opportunities within Dead Slough. The inclusion of the additional 90 acres, as shown on plate 3, by extending the levee system downriver approximately 3,000 feet was not selected due to negative impacts on existing aquatic conditions. This area is recognized as a valuable submergent/emergent vegetative zone and is a desirable backwater feature.

In Alternative C, different MSMU sizes were evaluated. Enlarging the size of the leveed area would increase the number of waterfowl the area could support. Waterfowl gains, however, must be weighed against fishery losses. The levee boundary was determined to be the best location to provide the maximum benefit to waterfowl and fishery resources. Extending the levee north of Dead Slough would negate any fishery benefits that would result from the dredging of Dead

Slough. It also could conceivably cause a significant increase in cost, since the levee would be adjacent to the main river channel and hence would require more protection from erosion. Extending the levee westward would place the levee in more open water and would necessitate a much longer tie-back to higher ground. In addition to the loss of fishery habitat, there would likely be a significantly higher cost to maintain the levee section in open water.

An alternative alignment which placed the levee on the north side of Dead Slough also was considered. This alternative would increase the MSMU by approximately 65 acres, but would greatly diminish fishery benefits from the dredging of Dead Slough.

In Alternative D, higher levee heights were considered. River events exceeding a 2-year frequency level during the months of June through December were studied. Out of 22 years of record, only 2 events exceeded a 2-year elevation during these months of MSMU operation. One of these events occurred in June following a long spring flood. This overtopping rate is acceptable, given the nature of the project and management objectives. Easements or property from abutting private landowners also would be required since the Corps has flood easements up to only the 2-year event. A 5-year levee could be used to keep floodwaters out, but water levels inside the levee could not be raised higher than elevation 550.8 without acquiring additional flood easements.

In Alternative E, diversion of flows and sediment was evaluated for all adjacent watersheds. Diversion of flows with associated sediment from watershed D was the only practical alternative. Flows from watersheds A, B, and C empty directly into the project site and would require miles of drainage ditches and channel relocations. However, areas where watersheds A, B, and C empty into the project site have natural alluvial fans with established semi-mature timber stands and low-level brush. These areas effectively settle and entrap much of the sediment from upland erosion before they reach Andalusia backwater areas. Should monitoring efforts after construction of the proposed project reveal substantial sediment inflow due to adjacent watersheds A, B, or C, coordination with appropriate soil conservation agencies should be effected to initiate upland erosion control programs.

In Alternative F, refuge bank protection was studied. During efforts to ensure that the downstream portion of the Refuge area would remain protected from Mississippi River flows, bank stabilization was proposed, as shown on plate 3. Field survey sections were taken and compared with 1936 topographic maps to determine relative movement of the bank line in protecting this area. These sections are shown on plates 24 and 25. It was concluded that this entire reach is not subject to river channel erosion. Shallow water depths of approximately 2 to 3 feet at flat pool are present throughout the entire reach. However, towboat propeller wash and wind-generated waves have contributed to tree line erosion with minor bank effects.

Comparison of the present survey sections with the 1936 elevations indicated that the substantial initial investment and recurring maintenance costs were not justified by providing bank stabilization in this reach. Furthermore, a

closure dam located down river at approximately river mile 461.2 effectively blocks Drury Slough from direct flows and indirectly provides additional stability to the left bank within the project site.

Alternative G consists of the improvement of the Dead Slough area for fishery purposes. One of the critical features of the improvement consists of a channel for fish access into the Dead Slough area that would be open all year. The opening of the channel required location in a sediment-free and erosion-free zone. Areas on plate 3 were studied as possible alternatives to the new channel. One location consisted of a natural flow area as shown. However, there is only about 2 to 3 feet of water in the river adjacent to this site for about 300 feet. Additionally, the bottom of this zone consists of several feet of soft sediments, indicating sediment deposition and questionable side slope stability during excavation and subsequent maintenance.

An additional mouth location also was studied, as shown on plate 3. The location of this proposed mouth could possibly increase sedimentation to the backwater refuge area by allowing uncontrolled entry of river flows into the upper end of the backwater area where such flows presently do not exist. The construction of the associated access channel from this point to the levee itself also could clear a desired natural buffer zone of mature trees which lies adjacent to the river. Clearing of this natural buffer would segment this portion of the refuge and possibly allow increased sedimentation in the backwater refuge area. These additional flows would create maintenance considerations by causing possible erosional scour against the new levee system, as well. Approximately 400 feet lies between the existing bank and main river channel, with only 3 feet of water clearance over a firm sand bottom. This condition would become a blockage to aquatic habitat during low flow, ice conditions. Excavation of a deeper channel in this vicinity also would encourage accelerated sedimentation in the mouth of the channel itself during Mississippi River high water events.

The location for the mouth of the access channel was selected as shown on plate 2. This location lies at the lower end of Scisco Chute and consists of an overland cut of about 400 feet. The entire Scisco Chute is a stable channel relative to sedimentation and scour and maintains minimum water depths from flat pool of 6 to 8 feet throughout the entire reach. Other evidence of erosion, such as downed bank trees, or sedimentation, such as sand or mud bars, is not present. Loss of the timber habitat is considered acceptable relative to the other negatives of considered alternatives. This access channel would provide deep water and reliable year-round fish access to the Dead Slough area.

Additional aquatic improvement also is proposed by means of excavation adjacent to the proposed levee, as shown on plate 2. This excavation would improve fish access to the Dead Slough area and provide additional deep water. Material from this excavation can be placed, as shown on plate 18, at the slough's edge to increase the section of the perimeter levee in this reach.

In Alternative H, interior improvements to the proposed MSMU were evaluated. Construction of drainage channels within the refuge itself was considered necessary to ensure adequate drainage to the pump station during drawdown periods. Without such drainage channels, water from the refuge would not reach the station in a timely manner, thus precluding efficient vegetation establishment during drawdowns. Material excavated from these ditches would be placed adjacent to the excavation zones and would create island habitat for additional refuge protection from land-based animals. These islands would be constructed as shown on plate 2. Construction of islands was considered a management objective to provide island-based refuge for migratory waterfowl.

Additional excavation within the MSMU, as shown on plate 2, would both provide a source of levee borrow and function as a low-water pool for survival of aquatic life.

7. SELECTED PLAN WITH DETAILED DESCRIPTION.

a. General Description. Alternatives B, E, G, and H were selected to be recommended for project construction. The construction of the 130-acre MSMU protected by a 2-year levee (Alternative B), selection of adjacent watershed flow and sediment diversion (Alternative E), Dead Slough aquatic improvement (Alternative G), and refuge drainage/island construction (Alternative H) all meet program objectives and are cost effective. This plan further provides balanced waterfowl habitat improvement and aquatic fishery habitat improvement.

The proposed project consists primarily of the construction of a 2-year event levee (elevation 550.8 MSL), 8,600 feet long and up to 110 feet wide from toe to toe, which will provide water level control on 130 acres of Refuge land, and a pump station capable of pumping 3,500 gallons per minute into the Refuge and 5,000 gallons per minute from the Refuge. Fill material for the levee will be excavated from Dead Slough, from the interior of the newly leveed Refuge, and from the diversion drainage ditch. This construction will create approximately 3.1 miles of channel (10,900 feet within the Refuge and 5,600 feet within Dead Slough). (See plates 9-12.) The Dead Slough channel adjacent to the levee will have a 60-foot bottom width. The configuration of the excavated channels within the leveed area will create islands totalling approximately 9 acres. These channels will allow fish to exit the leveed Refuge through a new water control structure into Dead Slough, and eventually the main river. The new mouth of Dead Slough will now empty into Scisco Chute. These channels also will facilitate the drawdown of water levels in the Refuge. The water control structure will be placed in the upstream portion of the levee to provide improved water level management, as well as permit fish egress and ingress to the levee interior.

The intermittent stream which now deposits sediment in the refuge backwaters will be rerouted directly to the main river (Scisco Chute). This will significantly decrease the sedimentation rate in the refuge and Dead Slough and will prolong the habitat life of the newly dredged channels and leveed area. The

new channel will be 2,430 feet long and 3 feet deep, with a 30-foot bottom width. This action will require clearing 3.7 acres of timber and excavating 11,700 cubic yards of material.

The levee has only been designed for the 2-year event. This level of protection will be sufficient to provide water level control for approximately 21 years out of 22, which is considered good for an MSMU. The levee elevation has been designed to withstand frequent overtopping without extensive damage. The lower portion of the levee will be armored to protect it from overflow during floods.

Dredging will be accomplished by mechanical means (i.e., backhoe or clamshell). In order for the mechanical equipment to operate, some trees along the immediate shoreline must be cleared. Approximately 7.4 acres of woodland and 2.5 acres of submergent/emergent wetland will be lost in a 40- to 100-foot-wide path along the Refuge's perimeter levee. The equipment for dredging Dead Slough also will operate along the levee alignment or from floating barges in Dead Slough.

A new access road approximately 3,600 feet long and an electrical transmission line also will be constructed, as shown on plate 14. These will follow the government property line from the pump station to a county road which abuts Corps land just outside the project site. About 2 acres of timber will be cleared for this access.

b. Perimeter Levee. The entire perimeter levee is designed to prevent a Mississippi River 2-year flood event from entering the Refuge. The 2-year flood elevation for the project site is elevation 550.8 feet MSL, which represents the elevation of the overflow reach of the levee as shown on plate 12 from station 24+17CE to station 30+17CE (600 feet). From station 24+17CE to station 9+40 (see profile on plate 15), the profile of the levee is approximately five times steeper than the natural flood profiles of the Mississippi River. The profile of the levee in this manner will ensure that the leveed system will be filled from the lower end by river events that exceed 2-year events. This profile should provide minimal maintenance to the levee in this reach. A detailed description of the operational features of the levee system is presented in Section 11.

(1) Station 12+21C to Station 11+00. This reach of levee, as shown on plate 8, consists of a 12-foot-wide crown with an approximate height of 4 feet. Typical section is shown on plate 18. Borrow for this approximately 1,300 feet of levee will come from excavation of the nearby diversion drainage ditch and from Dead Slough excavation.

(2) Station 11+00 to Station 8+00CE. This reach of levee of about 4,100 feet consists of an approximate 60-foot-wide levee crown with 4:1 (Horizontal:Vertical) side slopes, as shown in plan on plates 9, 10, and 11 and with typical section on plate 18.

Through detailed on-site meetings and investigations, this reach of the levee has been located adjacent to Dead Slough such that approximately 40 feet of the levee section lies on existing ground above flat pool (elevation 545.0)

with the remainder of the levee section lying within Dead Slough on land below flat pool (average elevation 544.0). This reach of the levee system has a substantially thicker section due to the placement requirement of adjacent Dead Slough excavation. The average height of this levee is 6 feet.

After construction, about half of the levee on the slough side will not require maintenance. The other half of this levee section will become the integral core of the levee and will require annual inspection and maintenance.

(3) Station 9+00CE to Station 24+17CE. This reach of the levee consists of approximately 1,600 lineal feet and has an average height of about 6 feet with 4:1 side slopes. This reach would be constructed using adjacent borrow sources, as shown on plates 12 and 13, with typical section on plate 18. The width of the levee crown of this reach will be 12 feet.

(4) Station 24+17CE to Station 30+17CE. This reach of the levee consists of approximately 600 feet crossing the most downstream area of the MSMU. Average height of this levee will be about 7 feet, with a 12-foot clay core and a 2-foot bedding and riprap blanket on the exterior for overflow and wave protection. This reach is shown on plate 12, with typical section on plate 18.

Borrow for this section of levee will be obtained from adjacent in-water excavation. Typical side slopes will be 4:1 due to construction considerations of the adjacent borrow.

(5) Station 30+17CE to Station 34+50CE. This 450-foot reach of the levee is shown on plate 12, with typical section on plate 19. This section of levee will tie into high ground and will be connected to the access road. Average height in this reach will be approximately 2 feet. Borrow will be obtained from areas adjacent to the access road.

c. Diversion Drainage Ditch. The plan view of the diversion ditch is shown on plate 8, with section shown on plate 18. The bottom width of the excavated ditch will be approximately 30 feet, with average depth of excavation of 3 feet. The drainage ditch has been sized to pass a 2-year precipitation event within bank.

The outlet of the diversion drainage ditch has been placed near flat pool in Scisco Chute which closely approximates the existing outlet and which should provide a maintenance-free outlet area.

The entire drainage diversion ditch is located on existing Government lands, so no additional easements/fee taking will be required. As shown on the typical section, an additional 10-foot-wide unsurfaced maintenance access service road also will be built during construction and used for maintenance after construction.

d. Dead Slough Excavation. As shown on plates 9, 10, and 11, with typical sections on plate 18, it is proposed to excavate approximately 110,000 cubic yards for Dead Slough aquatic improvement. The average bottom width of this excavation will be about 60 feet to elevation 536 MSL adjacent to the

levee. The average cut for this excavation will be approximately 7 feet. This material will be placed in the levee section adjacent to Dead Slough, as described in the above perimeter levee from station 11+00 to station 8+00CE.

An additional river access channel also will be constructed from Scisco Chute to the Dead Slough area. The approximately 1,100 feet of excavation will consist of a 30-foot-wide cut with an approximate 9-foot depth to elevation 536 MSL, with excavated material placed on adjacent land between stations 8E to 13E, as shown in section on plate 19.

e. Refuge Drainage/Islands. Interior Refuge drainage will be provided by the construction of excavated channels, as shown on plates 9, 10, 11, and 12. Two types of typical sections will be constructed as shown on plate 19.

Type I will consist of drainage channels constructed on both sides of an island. The excavated material would produce an approximate 45-foot-wide island at elevation 551 feet MSL.

Type II refuge excavation will consist of the drainage channel constructed on one side of the excavation with excavated material producing an approximate 10-foot-wide island with an elevation of 551 feet MSL. The overall length of the refuge drainage excavation will be about 8,600 feet. The profile of the refuge drainage excavation is shown on plate 17.

f. Pump Station. The pump station has been sized to evacuate the MSMU in approximately 14 days. Plan views and typical sections of the proposed station are shown on plate 20.

The pump station will be furnished with two pumps which will provide the capability to dewater the MSMU during drawdown times and to pump water from the Mississippi River into the MSMU. The sizes of these pumps will be 5,000 gpm and 3,500 gpm, respectively. The pump station will be manually energized when required and will operate automatically until de-energized. Overhead electrical power will be furnished adjacent to the proposed access road.

This station is being furnished with a trash rack on both the MSMU side and the river side due to flow reversals as described. The inverts of the station have been set consistent with refuge ditching and adjacent natural ground elevations. A sedimentation zone has been provided on the MSMU side with an overflow weir protecting the entrance to the station to minimize sediment entering the pump station during drawdown periods.

The station also will contain a 3-foot by 3-foot sluice gate to allow passage of gravity flows. The gate will be operated by an electrically driven motor.

Both pumps and the gate will be located within a cast-in-place concrete building structure. A vandal-resistant and durable structure will be provided.

g. Water Control Structure. A water control structure is proposed as shown in plan view on plate 21. The water control structure will consist of a 36-inch-diameter concrete conduit located within the proposed levee section. The conduit will be controlled by a 3-foot by 3-foot sluice gate which will be fitted with portable power source wrench fittings.

h. Access Road. Access to the pump station and levee system must be constructed as part of the project. Three general alternatives were considered in providing access, which are presented in table 7-1.

TABLE 7-1

Evaluation of Access Road Alternatives

Alternative Description	Pros	Cons	Estimated Initial Construction Cost	Remarks
Access on top of new levee from existing county highway (see plate 3).	Access from county highway provides year-round access reliability; provides good surveillance of refuge activities; provides good maintenance inspection of perimeter levee.	Need right-of-way from county highway for entrance; unauthorized public use could disturb refuge objectives; requires 7,600 feet crushed stone surface on top of the levee to build and maintain; requires 3,600 feet in length of clearing for electric service line.	$52,000	Not feasible due to cost, disturbance of refuge activities, and inaccessibility to pump station across overflow section once overflow commences.

TABLE 7-1 (Cont'd)

Alternative Description	Pros	Cons	Estimated Initial Construction Cost	Remarks
Access across private lands (see plate 3).	Access is remote from public view.	Requires approximately 3,700 feet of access road in addition to an overhead electric service road for electrical supply purposes; existing road to beginning of new access road not maintained by county.	$48,000	Not feasible due to no county maintenance of connecting road to road prior to new access road.
Access from downstream existing cottages.	Located entirely on Government lands and shortest distance, about 3,600 feet of electric supply would follow same route.	Access road would require filling and bank stabilization in vicinity of station 6+30F, as shown on plate 14; access must be coordinated with existing cottage leases and boat docks.	$65,000	Recommended access route.

The recommended access road consists of the construction of approximately 3,600 lineal feet of a 12-foot-wide service road, with typical sections shown on plate 19. The service road access also will be used by the local utility company for placement of overhead poles for electric power supply. IDOC personnel will control egress to the access road to prevent and minimize public access to the refuge area and consequent disturbance.

8. DESIGN AND CONSTRUCTION CONSIDERATIONS.

a. Existing Site Elevations. Construction of the levee and excavation equipment types is dependent upon existing water elevations during the construction period. During normal dry seasons of the year (June through December), conventional excavation equipment can be used for the majority of the levee, diversion drainage ditch excavation, Dead Slough excavation, and associated access road and drainage facilities.

b. Foundations of Structures. Prior to completion of the final plans and specifications, two deep borings will be required to confirm the presence of dense sand below the proposed pump station.

In the areas of the pump station and the water control structure, the levee shall be built 2 feet higher than final grade and consolidated for at least 3 months before excavation of the structure commences.

c. Borrow Sites/Construction Materials.

(1) Borrow Sites. Levee embankment sections with corresponding borrow sites are presented in table 8-1.

TABLE 8-1

Borrow Sources

Levee Embankment Station	Borrow Source	Remarks
Station 12+21C to 11+00	From diversion drainage ditch excavation.	Use Dead Slough excavation as additional borrow if quantity from diversion ditch is insufficient.
Station 11+00 to 8+00CE	From adjacent Dead Slough excavation.	Place uncompacted levee section. Construction activities for the embankment must allow passage of other construction equipment on a 10-foot-wide temporary access road without clear cutting mature timber. Based on further evaluation of soils data, consideration during final design consideration should be given to steepening side slopes and raising the levee profile higher than required (for disposal of excess Dead Slough

TABLE 8-1 (Cont'd)

Levee Embankment Station	Borrow Source	Remarks
		material). These actions would reduce the levee base width and impacts on the area.
Station 9+00CE to 24+17CE	Adjacent borrow creating permanent pool during drawdown using land-based equipment.	Place uncompacted levee fill.
Station 24+17CE to 30+17CE	Adjacent submergent borrow creating permanent pool during drawdown using floating plant equipment.	Possible alternative embankment material based on most economic section.
Station 30+17CE to 34+50CE	Adjacent to proposed access road.	Additional borrow is available in vicinity of station 23E.

(2) Construction Materials. Only common construction materials are required for this project. Construction of the access road will allow access to the proposed pump station and water control structure.

Riprap and bedding sources are available from nearby river terminals and probably would be transported by floating barge to the project site.

After construction of the access road, construction materials, including concrete, can be transported on the access road to the pump station and the water control structure using conventional equipment.

Because of the significant quantity of bedding and riprap, riprap sources were investigated and are readily available within several miles of the project site. These materials could be transported to the project site by floating barge.

d. Excavation Depths and Equipment. The basis for the proposed Dead Slough access channel and slough excavation is shown in table 8-2.

TABLE 8-2

Basis of Dead Slough Excavation

Elevation	Description
545.0	Flat Pool
-1.0	Low Flow Regulation
-6.0	Maintain Water Depth
-2.0	$25^{\pm}$ Years Sediment Storage a/
536.0	Selected Excavation Bottom

a/ An average rate of 1.0 inch per year was used as the average sedimentation rate for areas normally covered by water (below flat pool).

All excavation for the selected plan was presented and costs were estimated based on common excavation equipment such as draglines, backhoes, or clamshell (as opposed to hydraulic dredging). This equipment must be placed on floating plant for excavating the Dead Slough access channel, portions of the Dead Slough channel excavation, and adjacent to the riprapped weir overflow section. Adjacent disposal reaches have been based on use of typical equipment of this type with normal throw/placement distances.

An alternative to excavating the access channel and Dead Slough by floating plant will be further evaluated. Consideration will be given to using hydraulic dredging with placement in containment areas located on adjacent private property. Further coordination with adjacent agricultural property owners will proceed to effect possible alternate methods of dredged material placement. Construction easements will be required.

e. Erosion Control. Riprap is proposed on both sides of the weir overflow section of the perimeter levee to protect against both Mississippi River current during overflow and also against wave erosion during high flow events. The governing riprap design is based on wind-generated wave erosion at this location.

Riprap is also proposed in the area of the pump station for protection of pump embankment slopes and at the entrance of the new Dead Slough Access channel.

An estimated width of approximately 200 feet of existing mature timber will remain in most reaches between the new levee and the Mississippi River to provide a natural buffer from Mississippi River high flood events. This natural undisturbed zone should adequately protect the new levee in Dead Slough.

Seeding will be required immediately following the diversion drainage ditch excavation and also on the proposed levee sections to ensure face stability from erosion forces.

f. Permits. The requirements of Section 404 of the Clean Water Act will be completed prior to submission of this report for final approval, including Section 401 Water Quality Certification. An additional Construction-in-the-Flood Plain permit from the Illinois Division of Water Resources also will be required and completed prior to final submission.

9. ENVIRONMENTAL EFFECTS.

a. Summary of Effects. The effects of the Selected Plan are summarized in table 9-1.

b. Economic and Social Impacts.

(1) Community and Regional Growth. No significant impacts to the growth of the community or region will result from the project.

(2) Community Cohesion. No adverse impacts to community cohesion will be noticed, due to the nature of the project and its limited area of influence. Since the site is managed as a fish and wildlife refuge by the IDOC and is located in a rural surrounding with limited recreational opportunities, it will result in only a slight increase in recreation visitation to the area.

(3) Displacement of People. No residential relocations will be necessitated by the project.

(4) Property Values and Tax Revenues. The potential value of property at the project site could increase slightly following completion of the project. Since the affected property is in Federal ownership, an increase in its value will not increase local tax revenues.

(5) Public Facilities and Services. The project site is federally owned and zoned for low density recreation. The project will positively impact public facilities by enhancing fish and wildlife habitat and by improving conditions for recreational boating. If no action is taken, recreational opportunities at the Refuge will be reduced and a once important fishery, migratory waterfowl, and furbearer area will be transformed into lowland brush habitat.

(6) Life, Health, and Safety. Currently, the Andalusia Wildlife Refuge poses no threats to life, health, or safety of recreationists or others in the area. The project will not affect current conditions regarding these areas of concern.

TABLE 9-1

Effects of the Preferred Plan on Natural and Cultural Resources

Resource	Effect
Air Quality	No effect
Endangered/Threatened Species	No effect
Habitat Type	
Bottomland Hardwoods	Potential negative impacts on 50-60 acres of bottomland within leveed Refuge due to inundation from water level management; 7.4 acres lost due to levee construction (5.3 acres of which is forested wetland), 3.7 acres lost due to drainage channel relocation; .78 acre at the mouth of Dead Slough; 2 acres from new access road.
Emergent/Submergent Wetlands	2.5 acres filled due to levee construction; 7.2 acres in Dead Slough converted to deep water aquatic from dredging; 9 acres within Refuge converted to nesting islands. 10 acres within Refuge MSMU converted to deep aquatic from channel dredging.
Fisheries	Dredging of Dead Slough will replace 7.2 acres of submergent/emergent with 7.2 acres of new deepwater/backwater habitat and reconnect the now isolated slough with the main river.
Waterfowl	Greatly improved habitat for migratory waterfowl on 130 acres of wetland through improved water level control.
Floodplain	No measurable increase in flood heights.
Historic & Cultural Properties	No effect
Prime & Unique Farmlands	No effect
Water Quality	Temporary increase in turbidity during construction of levee and channel dredging. Significantly improved water quality in Dead Slough after construction (i.e., improved DO and water circulation).

(7) Employment and Labor Force. Project construction would slightly impact short-term employment in the project area. Rock Island County has a labor pool of large enough size to absorb project needs without noticeable impact. No impacts to long-term employment will result from the project.

(8) Business and Industrial Development. Changes in business and industrial activity during the after-project construction will not be noticed. The project will require no business relocations.

(9) Farm Displacement. No farms will be affected by the environmental enhancement project, as the project site is located entirely on federally owned land.

(10) Noise Levels. No significant long-term noise impacts will result from the project. Heavy machinery will generate an increase in noise during construction. This increase would disturb recreationists in the immediate project vicinity. However, the project site is located in an area with limited residential or other types of development.

c. Natural Resource Impacts.

(1) Man-Made Resources. The proposed new levee will be a man-made resource that will be managed and maintained to provide improved resting and feeding habitat for migratory waterfowl. There are no existing man-made resources in the immediate project area, other than the 9-foot navigation channel project which will be unaffected.

(2) Natural Resources.

(a) Bottomland Forest. The most significant impact from project construction will be the clearing of bottomland forest for the levee right-of-way. Approximately 7.4 acres of hardwoods along the levee alignment must be cleared which consists of mixed-age oak, hickory, silver maple, hackberry, cottonwood, and elm. The timber through which the levee passes is the only stand in the project area containing mast trees (i.e., oak and hickory). In order to minimize the loss of these trees, the levee will be placed as close to the shoreline of Dead Slough as possible. This shoreline alignment is also necessary to allow mechanical excavation of borrow material from Dead Slough. Approximately 4.5 acres along the relocated drainage ditch and the new Dead Slough entrance also will be cleared. Overall, these trees consist of less mature silver maple and cottonwood. Another 2 acres of mostly bottomland hardwoods will be cleared for the access road and power transmission line. An additional 50 to 60 acres of silver maple/cottonwood within the levee interior may be affected by artificial water level management within the Refuge. These tree species, however, are adapted to long periods of inundation during spring and fall. The severity of impact will depend primarily on the length of time that trees are artificially inundated during the summer growing season and the depth of water.

(b) Fisheries Resources. The proposed project will reduce the almost annual fish kills that now occur in Dead Slough. The new deepwater habitat will allow ingress and egress from Dead Slough to both the Mississippi

River main channel and the Refuge interior for spawning and nursery habitat. The creation of the deepwater channels adjacent to shallow vegetated areas will create ideal conditions for both forage and sport fishes. This is important for spawning, cover, and allowing egress when refuge water levels are drawn down in early summer. The creation of deepwater aquatic habitat in a backwater area will provide a critically needed wintering habitat for several fish species (Bodensteiner and Sheehan, 1988). [1] The net project result will be increased fish populations both inside and outside the project.

(c) Waterfowl Resources. The proposed project will create a reliable food supply for fall migratory waterfowl. The new levee and pump station will allow waterfowl biologists to manipulate water levels on 130 acres of wetland to enhance waterfowl food production. The levee also will prevent 2-year flood events from destroying the food crop, significantly improving the Refuge's capacity to provide food and refuge.

The configuration of the channel dredging within the leveed area will create several low elevation islands that will promote nesting of Canada geese. However, the anticipated number of geese using these islands is probably less than a dozen nesting pairs.

(d) Other Wildlife. The increased deep and shallow water habitat will make the area more attractive to semi-aquatic mammals (i.e., muskrat, beaver, and possibly river otter), amphibians and reptiles (i.e., turtles, water snakes), and shorebirds. The loss of mast-producing trees along the levee alignment will decrease available food for some species (i.e., squirrel, deer, wood duck).

(3) Water Quality. The water quality of Dead Slough will improve as a result of the project. The increased depth and reconnection of the slough with the main river channel will improve water circulation, dissolved oxygen, and decrease the rapid fluctuation of water temperature that now occurs. The dredging of Dead Slough will increase turbidity levels during construction. This will have negligible adverse effects since the existing water quality is poor. The relocated drainage channel will improve water quality in Dead Slough and the leveed area. The decrease in sediment input from this stream will improve water quality and prolong the project's life. A more detailed discussion of water quality and prolonged impacts can be found in appendix B.

(4) Air Quality. No effect.

(5) Endangered Species. The only observed endangered species known to occur in the immediate project vicinity is the bald eagle. During late fall and early winter, migratory eagles are frequently sighted along the

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[1] Bodensteiner, Leo and Robert Sheehan, 1988. Implications of Backwater Habitat Management Strategies to Fish Populations. 43rd Annual Upper Mississippi River Conservation Committee Meeting, Peoria, Illinois, March 8-10, 1988.

entire river in the Rock Island District. As ice cover forms on the river in December, the eagles concentrate in critical wintering locations near the open tailwaters of the locks and dams.

Project construction may discourage use of the area by eagles during fall, but will have no effect on wintering eagles which utilize other wintertime habitats. Based on this evaluation, the project will have no effect on bald eagles or any other State or federally endangered species.

(6) Wetlands. Under Corps wetland determination guidelines, any area below 547.0 feet MSL is wetland regulated by the Corps. Using this criterion, approximately 18 acres of palustrine forested, scrub-shrub, emergent, and aquatic bed wetland classes are common in Pool 16. This loss of wetland will have no significant impact on local wetland functions. Operation of the new levee will be filled or cleared as a result of the project. Although these wetlands are valuable from several perspectives, these palustrine wetland classes are common in Pool 16. This loss of wetland will have no significant impact on local wetland functions. Operation of the new levee will impose a more regular hydrologic regime upon the wetlands within the levee. Regular and consistent water level control may lead to a decrease in the diversity of wetland types that now exist within the levee. The extent to which this decreased diversity may occur will depend upon water level management and the variability of the substrate elevation (for example, the more uniform the water depth, the more likely that one wetland class will tend to dominate).

(7) Cultural Resources. An archeological survey and geomorphological evaluation of the proposed project area was conducted under the direction of archeologist David Stanley and geomorphologist Jeffery Anderson of Bear Creek Archeology and Donohue and Associates, respectively, from July 23, 1988, to August 1, 1988. A detailed archeological and geomorphological evaluation of the proposed levee alignment, diversion drainage ditch, dead slough access channel, and access road failed to locate any significant historic properties. Isolated chert flakes were present in an area where the proposed access road crosses an alluvial fan. However, these were thought to be relocated from a higher elevation outside the project area. No intact cultural deposits or features were encountered. Based on these field results, it is the conclusion that the proposed Andalusia EMP project will not impact any significant historic properties. By letter dated September 7, 1988, the Illinois State Historic Preservation Officer concurred with this finding.

(8) Relationship of the Proposed Project to Land-Use Plans. The present land use of the entire project area is the management of fish and wildlife resources. This project is compatible with this land use and is designated to enhance and promote these land-use plans. The USFWS also has determined that the proposed project is compatible with existing refuge goals and objectives. (See Appendix A.)

d. Adverse Effects Which Cannot Be Avoided. The clearing of approximately 13 acres of bottomland hardwoods during construction is unavoidable. The possible indirect loss of 50 to 60 acres of additional trees within the leveed area from periodic flooding may be unavoidable if the project is managed as intended.

e. Short-Term Use Versus Long-Term Productivity. The proposed project will improve both the short- and long-term productivity in terms of fishery and waterfowl habitat. The newly leveed area will provide a reliable long-term feeding and resting refuge for waterfowl. Productive deepwater fish habitat will be constructed at the expense of locally abundant emergent wetland occasionally used as fish spawning habitat by some species.

f. Irreversible or Irretrievable Resource Commitments. Aside from the commitment of funds, labor, and construction materials, there will be no permanent loss of natural resources except for the loss of forest and wetland replaced by the project.

g. Compliance with Environmental Quality Statutes. The proposed project complies with all applicable laws and regulations listed in table 9-2.

10. SUMMARY OF PROJECT ACCOMPLISHMENTS.

The proposed project will benefit three major areas: improve water quality by reducing sedimentation in the project area; increase the quantity and quality of reliable waterfowl habitat; and increase fishery habitat.

Construction of the diversion ditch will reduce the present sediment load into the area by approximately 15 percent. This reduction will increase the water quality in the Dead Slough area by reducing suspended solids and agricultural runoff chemicals.

Construction of the moist soil unit with accompanying water level control will provide a reliable resting and feeding area for migrating waterfowl. The MSMU will not only provide a readily available food source in existing open areas, but also an additional food source within the inundated "green tree" portion of the unit. Without implementation of the proposed project, migrating waterfowl will not have reliable resting and feeding areas along this reach of the river for approximately 70 miles. The present usage of approximately 2,000 waterfowl use days should significantly increase due to the project.

The proposed levee construction will prevent most fall floods from entering the MSMU. With the provision of the pump station and the levee system, waterfowl biologists will have the capability to manipulate water levels for optimum waterfowl support on approximately 130 acres of prime Refuge lands.

Aquatic habitat will be improved by providing year-round access to Dead Slough. Dead Slough experienced increasing numbers of fish kills due to low dissolved oxygen. The proposed project should eliminate these conditions by connection to the main river and by providing deeper channel areas. The construction of the deep water channels adjacent to the shallow vegetated areas of Dead Slough will provide ideal conditions for both forage and sport fishes. The construction of deeper channels in the backwater area of the river will provide critically needed wintering habitat for several fish species.

TABLE 9-2

Compliance of the Selected Plan with WRC-Designated Environmental Statutes

Federal Policies	Compliance
Archaeological and Historic Preservation Act, 16 U.S.C. 469, et seq.	Full compliance
Clean Air Act, as amended, 42 U.S.C. 1857h-7, et seq.	Full compliance
Clean Water Act (Federal Water Pollution Control Act) 33 U.S.C. 1251, et seq.	Full compliance
Coastal Zone Management Act, 16 U.S.C. 1451, et seq.	Not applicable
Endangered Species Act, 16 U.S.C. 1531, et seq.	Full compliance
Estuary Protection Act, 16 U.S.C. 1221, et seq.	Not applicable
Federal Water Project Recreation Act, 16 U.S.C. 460-1(12), et seq.	Full compliance
Fish and Wildlife Coordination Act, 16 U.S.C. 1401, et seq.	Full compliance
Marine Protection Research and Sanctuary Act, 33 U.S.C. 1401, et seq.	Not applicable
National Environmental Policy Act, 42 U.S.C. 4321, et seq.	Full compliance
National Historic Preservation Act, 16 U.S.C. 470a et seq.	Full compliance
Rivers and Harbors Act, 33 U.S.C. 403, et seq.	Full compliance
Watershed Protection and Flood Prevention Act, 16 U.S.C. 1001, et seq.	Full compliance
Wild and Scenic Rivers Act, 16 U.S.C. 1271, et seq.	Not applicable
National Farmland Protection Policy Act, 7 U.S.C. 4201, et seq.	Full compliance

11. OPERATION, MAINTENANCE, REPAIR, AND REHABILITATION CONSIDERATIONS.

a. Project Data Summary. Table 11-1 presents a summary of project data.

b. Operation. The estimated costs for operation, maintenance, repair, and rehabilitation of the selected plan are presented in table 13-2.

The gate of the pump station and the water control structure should be operated in an open position, except during periods of MSMU management by IDOC personnel. During desired drawdown periods, the gate of the water control structure and the pump station should be closed and the pump station activated for drawdown purposes. The pump station must be manually activated but will automatically turn off at a low water level of 542.0 MSL. During drawdown periods, the pump station will automatically turn on at elevation 542.5 MSL to maintain the 542.0 drawdown elevation.

After drawdown has occurred and once vegetation has been established in the MSMU, either adjacent tributary inflow, seepage, or opening of the water control structure gate or the pump station gate will allow water into the MSMU area. Use of gates should be controlled to achieve desired water levels consistent with vegetative growth.

When it is desired to pump from the river into the MSMU, the station must be manually activated and will continue pumping automatically until elevation 547.0 MSL (which can be adjustable to elevation 550.8, the elevation of the levee overflow). It is anticipated that ponding levels higher than elevation 547.0 will cause damage to adjacent agricultural fields during crop growing seasons. Coordination between the IDOC and adjacent property owners during non-crop season may be effected to realize higher MSMU elevations than 547.0. The highest MSMU elevation of 550.8 MSL will occur when water reaches the elevation of the overflow weir.

During periods of drawdown and when river events reach elevation 550.0 MSL with predicted stage to increase, the gates of the water control structure and the station should be opened in efforts to fill the interior of the levee without overtopping. Should the river stage exceed 550.8 MSL prior to filling using the existing water control structure and pump station conduits, the remainder of overflow will occur by means of a riprapped overflow weir station.

The Rock Island District will prepare an operation and maintenance manual for the IDOC during the design phase.

TABLE 11-1

Andalusia Refuge Project Data Summary of Proposed Features

Perimeter Levee		
Embankment fill	122,000	Cubic Yards
Length	8,600	Feet
Crown elevation	552.8	Station 12+21C to Station 11+00
	552.8 to 551.8	Varies from Station 11+00 to Station 24+17CE
	550.8	From Station 25+17CE to Station 29+17CE
	551.8	From Station 30+17CE to Station 34+50CE
Side slopes	4:1	Horizontal to vertical from Station 12+21C to 8+00CE. Slopes flattened for overflow and soft material placement purposes
	4:1	From Station 9+00CE to Station 34+50CE
Armored overflow levee section		
Length	600	Feet
Overflow elevation	550.8	MSL
Riprap	3,370	Tons
Diversion Drainage Ditch		
Approximate length	2,430	Feet
Average width	30	Feet
Average depth	3	Feet
Bottom slope	.0025	Foot per foot
Watershed area	1,152	Acres
Capacity of channel	340	CFS (2-year precipitation event)

TABLE 11-1 (Cont'd)

Dead Slough Channel Excavation		
Adjacent to Levee		
Approximate length	4,500	Feet
Width at bottom	60	Feet
Bottom elevation	536.0	MSL
Volume of excavation	87,000	CY
River Access Excavation		
Approximate length	1,100	Feet
Width at bottom	30	Feet
Bottom elevation	536	MSL
Volume of excavation	23,000	CY
Refuge Drainage/Island Construction		
Interior drainage with islands		
Length	8,600	Feet
Width	40	Feet
Bottom elevation	542.0±	MSL
No. of islands	8	Each
Area of an island above elevation 545.0	9.0	Acres
Interior drainage for adjacent levee borrow		
Length	2,300	Feet
Width at bottom	20	Feet
Bottom elevation	536.0	MSL
Pump Station		
Submersible pumps		
Emptying pump	1	Each: 5,000 gpm at 14.3 TDH
Filling pump	1	Each: 3,500 gpm at 7.8 TDH
Sluice gate	1	Each: 3 feet x 3 feet
Operating elevations		
Refuge max. elevation	550.8	MSL (overflow elevation)
Refuge min. elevation	542.0	MSL
Sump floor elevation	539.5	MSL
Equipment floor elevation	560.0	MSL (100-year Mississippi River event)

TABLE 11-1 (Cont'd)

Electric power source		
Primary supply	7,620	Volts, 1 phase
Secondary station supply	480/277	Volts, 1 phase
Transformer size	37.5	KVA, 1 phase
Power converter	37.5	KVA, 3 phase
Trash racks upper and lower ends	2	Each
Water Control Structure		
Sluice gate	1	Each: 3 feet x 3 feet
Invert	542.0	MSL
Access Road		
Approximate length	3,600	Feet
Width	12	Feet, with crushed stone surface

c. Maintenance, Repair and Rehabilitation. The proposed features have been designed to ensure low annual maintenance requirements with the estimated annual maintenance, repair, and rehabilitation costs presented in table 13-2. These quantities and costs may change during final design. The principal maintenance features consist of levee inspection, mowing, diversion ditch cleanout, levee repair as needed, riprap replacement, and pump station maintenance.

12. POST-CONSTRUCTION PERFORMANCE MONITORING.

Post-construction performance evaluation/monitoring by the IDOC will be described in detail in the Operation and Maintenance Manual. A summary of post-construction performance is presented in table 12-1. This qualitative evaluation will be completed and submitted by the IDOC annually. Physical, chemical, and biological monitoring parameters are presented in table 12-2, with entries completed and submitted by the IDOC as shown. Measurement intervals shown are minimums and may be performed more often by the IDOC as necessary to reflect appropriate changes. Established sedimentation ranges which are defined and reproducible traverses are shown on plates 23, 24, and 25.

TABLE 12-1

Post-Construction Performance Monitoring

Project Objectives	Standard	Rating/Evaluation
Enhance migratory waterfowl habitat	Increase migratory waterfowl vegetation.	-
	Increase waterfowl resting and loafing area.	-
	Increase waterfowl usage.	-
Enhance aquatic habitat	Increase volume of aquatic habitat.	-
	Ensure year-round aquatic habitat access to river/deep water.	-
	Increase water quality within project.	-
	Increase fish usage.	-
Decrease/retard Refuge sedimentation	Decrease adjacent tributary sediment load into project area.	-

TABLE 12-2

Suggested Physical, Chemical, and Biological Monitoring Plan

Project Objectives	Monitoring Plan	Measurement Interval (Years)
Enhance migratory waterfowl habitat	Perform waterfowl inventories during migration to assess effects of the MSMU	2
	Perform vegetation inventories by elevation by time of year within the MSMU to assess effects of the pump station and to optimize MSMU management.	2
	Perform other monitoring as needed.	-
Enhance aquatic habitat	Identify dissolved oxygen concentrations during critical seasons at fixed stations to verify Dead Slough excavation effectiveness.	1
	Perform soundings of excavated Dead Slough access and channel excavation to provide estimates of channel sloughing.	5
	Perform fishery inventories to assess effects from excavation of Dead Slough.	2
	Perform other monitoring as needed.	-
Decrease/retard Refuge sedimentation	Establish base sedimentation ranges in the project area and perform sedimentation measurements at same ranges to assess effects of the proposed project.	5
	Perform other monitoring as needed.	-

13. COST ESTIMATES.

A detailed estimate of initial construction costs is presented in table 13-1. A detailed estimate of operation, maintenance, repair, and rehabilitation costs is presented in table 13-2. Quantities may vary during final design and construction.

TABLE 13-1

Andalusia Refuge Initial Construction Detailed Estimate of Cost
(July 1988 Price Levels)

Item	Quantity	Unit	Unit Cost ($)	Total Cost ($)
Perimeter Levee				
Clearing/grubbing	10	AC	3,175.00	31,750
Embankment fill	122,000	CY	2.50	305,000
Bedding	1,120	TN	22.00	24,640
Riprap	3,370	TN	24.0	80,880
Seeding	10	AC	1,650.00	16,500
				458,770
Existing Ditch Relocation				
Clearing/grubbing	4	AC	3,175.00	12,700
Excavation	11,700	CY	3.00	35,100
Seeding	4	AC	1,650.00	6,600
				54,400
Dead Slough Improvement				
Clearing/grubbing	1	AC	3,175.00	3,175
Excavation for adjacent levee	87,000	CY	3.00	261,000
Excavation for river access	23,000	CY	5.00	115,000
Seeding	0.5	AC	1,650.00	825
				380,000
Refuge Improvement				
Excavation with side cast Placement for islands	48,000	CY	3.00	144,000
Excavation for adjacent levee	27,000	CY	3.00	81,000
				225,000
Pump Station				
Civil/site work	1	JOB	SUM	195,000
Pumps, motor, control, gates	1	JOB	SUM	45,000
Overhead power supply	1	JOB	SUM	15,000
				255,000
Water Control Structure Between Dead Slough and Refuge	1	JOB	SUM	45,000
Access Road				
Clearing/grubbing	2	AC	3,175.00	6,350
Excavation	3,000	CY	3.00	9,000
Embankment fill	4,100	CY	3.00	12,300
Crushed stone surface	1,240	TN	14.00	17,360
Riprap	825	TN	24.00	19,800
				64,810
Subtotal				1,482,980
Contingencies				274,020
				1,757,000
Engineering and Design				217,000
Supervision and Administration				121,000
TOTAL PROJECT				$2,095,000

TABLE 13-2

Andalusia Refuge Estimate of Annual Operation, Maintenance, Repair, and Rehabilitation Costs
(July 1988 Price Levels)

Item	Quantity	Unit	Unit Cost ($)	Total Cost ($)
Operation a/				
Pump station energy	12,000	kWh	.10	1,200
Gate operation	20	Hr	17.00	340
Performance monitoring	40	Hr	30.00	1,200
Subtotal-Operation				2,740
Maintenance, Repair, and Rehabilitation				
Levee inspection	40	Hr	17.00	680
Levee mowing (4 mowings per year)	32	AC	30.00	960
Diversion ditch cleanout	267	CY	3.00	801
Levee repair and rehabilitation	130	CY	6.00	780
Riprap replacement	33	TN	24.00	792
Access road crushed stone	10	TN	20.00	200
Pump station maintenance (debris and sediment removal, mechanical/electrical)	80	Hr	30.00	2,400
Subtotal-Maintenance, Repair, and Rehabilitation				6,613
Subtotal				9,353
Contingencies				2,047
Total per year				$11,400

a/ Natural seeding for plant establishment assumed.

14. REAL ESTATE REQUIREMENTS.

a. General. All project features are located on Corps of Engineers-owned General Plan lands. These lands are managed under a Cooperative Agreement between the Department of Interior, USFWS, and the Corps of Engineers dated February 14, 1963. Management of these project lands is administered by the IDOC under a third party Cooperative Agreement between the USFWS and IDOC.

b. Local Cooperation Agreements/Cost-Sharing. Funds for the initial construction of the proposed project are proposed for 100 percent Federal funding. The Andalusia Refuge project is part of the Mark Twain National Wildlife and Fish Refuge system. The Water Resources Development Act of 1986 (Public Law 99-662) is the basis for the first cost Federal funding and provides:

> Section 906. FISH AND WILDLIFE MITIGATION
>
> (e) ... the first cost of such enhancement shall be a Federal cost when - such activities are located on lands managed as a national wildlife refuge.

A local cooperation agreement is required with the IDOC for operation, maintenance, repair, and rehabilitation of the project features. A draft local cooperation agreement has been included in this report as Appendix C. Estimated operation, maintenance, repair, and rehabilitation costs are presented in table 13-2.

c. Construction Easements. Minor easements may be required for construction from the existing county highway or local privately owned farm accesses to facilitate access to the construction site. Additional construction easements may be required if adjacent agricultural landowners agree to accept dredged material on their lands. Construction easements with such parties will be obtained for construction prior to contract advertisement.

15. SCHEDULE FOR DESIGN AND CONSTRUCTION.

Table 15-1 presents a schedule of project completion steps.

16. IMPLEMENTATION RESPONSIBILITIES AND VIEWS.

a. Corps of Engineers. The Corps of Engineers, Rock Island District, is responsible for project management and coordination with the USFWS, the IDOC, and other affected agencies. The Rock Island District will prepare and submit the subject DPR; program funds; finalize plans and specifications; complete all National Environmental Policy Act requirements; advertise and award a construction contract; and perform construction contract supervision and administration.

TABLE 15-1

Project Implementation Schedule

Requirements	Scheduled Date
Submission of Draft Definite Project Report (DPR) to Corps of Engineers, North Central Division and participating agencies for Review	Sep 88
Formal Distribution of DPR for public and agency review	Nov 88
Submit final and public reviewed DPR to North Central Division	Jan 89
Receive plan and specification funds	Feb 89
Obtain construction approval and approval of draft local cooperation agreement for execution by Assistant Secretary of the Army (Civil Works)	Mar 89
Initiate acquisition of real estate permits and execution with State of Illinois of local cooperation agreement	Apr 89
Submit local cooperation agreement signed by the non-Federal sponsor to the Office of the Chief of Engineers for execution by the Assistant Secretary of the Army (Civil Works)	May 89
Submit final plans and specifications to North Central Division for review and approval and to participating agencies for review	May 89
Obtain real estate permits	Jun 89
Obtain approval of the local cooperation agreement by Assistant Secretary of the Army (Civil Works)	Jun 89
Obtain approval of the plans and specifications	Jun 89
Advertise contract	Jul 89
Complete construction	Dec 90

b. U.S. Fish and Wildlife Service. The USFWS should ensure that all proposed features are compatible with Refuge objectives and management strategies.

c. Illinois Department of Conservation. The IDOC is responsible for 100 percent operation, maintenance, repair, and rehabilitation costs as estimated in table 13-2. A local cooperation agreement must be executed between the Government and the IDOC prior to initiation of construction contract advertisement proceedings. The IDOC has volunteered to assume 100 percent of the annual OMRR costs.

17. COORDINATION, PUBLIC VIEWS, AND COMMENTS.

a. Coordination Meetings. Close coordination between Corps of Engineers, USFWS, and IDOC personnel was effected during the planning period. A listing of meetings follows:

(1) November 29, 1986 - Onsite meeting to discuss project objectives and scope.

(2) March 4, 1987 - Meeting at Rock Island District, Corps of Engineers, to further scope project and define objectives.

(3) February 4, 1988 - Meeting at Rock Island District, Corps of Engineers, to discuss/coordinate preliminary DPR.

(4) June 29, 1988 - Meeting at Rock Island District, Corps of Engineers, an onsite review of proposed project features and proposed timber clearing practices.

b. Environmental Review Process. This project meets the requirements of the National Environmental Policy Act, as evidenced by the Environmental Assessment, which is an integral part of this report, and Finding of No Significant Impact.

18. CONCLUSIONS.

Andalusia Refuge has been recommended to the Corps of Engineers, Rock Island District, by various inter-agency coordination committees for priority inclusion into the Environmental Management Program. With proposed project features in place, the Refuge will enhance migratory waterfowl habitat by providing an increased food source within a reliable water-control unit and will improve aquatic fisheries. The Refuge is ideally sited in Pool 16 as a resting area for Mississippi River flyway waterfowl.

Sedimentation from both adjacent watersheds and the river has been the principal cause of the general waterfowl and fishery habitat degradation. Sedimentation has converted a former backwater fishery in Dead Slough into a shallow, land-locked area with no present fishery.

Alternative B (130-acre MSMU protected by 2-year levee), Alternative E (adjacent watershed flow and sediment diversion), Alternative 6 (Dead Slough aquatic improvement), and Alternative H (Refuge drainage/island construction) all meet project objectives and are compatible with Refuge management objectives.

19. RECOMMENDATIONS.

I have weighed the accomplishments to be obtained from this environmental enhancement project against its cost and have considered the alternatives, size, and scope of the proposed project. In my judgement, the proposed project is a justified expenditure of Federal funds. I recommend that the Secretary of the Army approve construction of a 130-acre Moist Soil Management Unit, protected by a 2-year levee, adjacent watershed flow and sediment diversion, Dead Slough aquatic improvement, and Refuge drainage/island construction for habitat rehabilitation and enhancement of Andalusia Refuge in Rock Island County, Illinois. The total estimated Federal construction cost of the habitat project is $1,870,000, which amount would be a 100 percent Federal cost according to Section 906(e)(3) of Public Law 99-662. I further recommend that funds in the amount of $24,000 be allocated as quickly as possible for the preparation of plans and specifications.

20. FINDING OF NO SIGNIFICANT IMPACT.

Having reviewed the information contained in this environmental assessment, I find that construction of the Andalusia Refuge Habitat Rehabilitation and Enhancement project will have no significant adverse impacts on the environment. This project is not a major Federal action and, therefore, preparation of an Environmental Impact Statement (EIS) is not required. This determination may be reevaluated if warranted by later developments. Factors that were considered in making this determination were:

a. The project will significantly improve the quality of fish and wildlife habitat.

b. Aside from the loss of bottomland forest and wetland, this project will have negligible adverse impacts on aquatic and terrestrial resources.

c. Public review of this document has resulted in no significant adverse comments.

_____
Date

Neil A. Smart
Colonel, U.S. Army
District Engineer

CORRESPONDENCE

APPENDIX A

UPPER MISSISSIPPI RIVER SYSTEM
ENVIRONMENTAL MANAGEMENT PROGRAM
DEFINITE PROJECT REPORT
WITH INTEGRATED ENVIRONMENTAL ASSESSMENT

ANDALUSIA REFUGE
REHABILITATION AND ENHANCEMENT

POOL 16, MISSISSIPPI RIVER MILES 462 THROUGH 463
ROCK ISLAND COUNTY, ILLINOIS

APPENDIX A
CORRESPONDENCE

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Illinois Department of Conservation
life and land together

LINCOLN TOWER PLAZA • 524 SOUTH SECOND STREET • SPRINGFIELD 62701-1787
CHICAGO OFFICE • ROOM 4-300 • 100 WEST RANDOLPH 60601
Michael B. Witte, Director • James C. Helfrich, Assistant Director

April 17, 1986

District Engineer
U.S. Army Engineer District, Rock Island
ATTN: Planning Division, PD-R
Clock Tower Building - P.O. Box 2004
Rock Island, IL 61204-2004

Dear Sirs:

Enclosed is the appendix for the engineering and design of the proposed project at Andalusia Refuge to be part of the Upper Mississippi River System-Environmental Management Program.

If you have any questions or require further information, please contact me.

Sincerely,

William R. Donels

William R. Donels
Landscape Architect
Division of Planning

WRD:sm
Encl.

cc: Gary McCandless
Bill Bertrand
Bob Thornberry

UPPER MISSISSIPPI RIVER SYSTEM
ENVIRONMENTAL MANAGEMENT PROGRAM
GENERAL PLAN APPENDIX
FOR ENGINEERING AND DESIGN

Andalusia Refuge
Pool 16, Upper Mississippi River
Rock Island County, Illinois

INTRODUCTION

Project Authority

The 1985 Supplemental Appropriations Act (Public Law 99-88) provides authorization and appropriations for an environmental management program for the Upper Mississippi River system that includes fish and wildlife habitat rehabilitation and enhancement. The proposed project would be funded under this authorization.

Project Location

Within the Upper Mississippi Wildlife and Fish Refuge between river mile 462 and 463, immediately south of Dead Slough and north of Illinois City are 256 acres managed by the State of Illinois, Department of Conservation (see attachment).

Resource Problems and Opportunities

Presently, there are no low water control systems located in Pool 16. The construction of a low water control structure system would greatly enhance habitat and its management. The lack of shallow water habitat with submergent/emergent aquatic plants has adversely affected waterfowl, furbearer and fisheries resources within this pool of the Mississippi River.

Proposed Solution

The proposed project would involve repair of an existing levee and construction of two additional low water leveed about 7,200' which would tie into high ground along the south edge of the impoundment to provide 130 acres of refuge area. It would include two 12" water control structures and some associated ditching that would accommodate portable pumps.

PROJECT REQUIREMENTS

Estimated Engineering and Design Cost

Estimated engineering and design costs for this project are $43,000 broken down as follows:

1.	Dike condition, topographic and soils surveys	$ 8,000
2.	Design of structures	17,000
3.	Coordination, environmental documentation & review	18,000
4.	Total	$43,000

The engineering and design costs would be 100 percent Federal because the project is on the Upper Mississippi Wildlife and Fish Refuge and

because the project's primary purpose is habitat improvement for migratory waterfowl.

The Illinois Department of Conservation has estimated project implementation costs to be $185,000. This cost estimate would be refined during the engineering and design phase.

Compliance with the National Environmental Policy Act of 1969 and other environmental laws and regulations would be documented during the engineering and design phase.

Project Participants

The primary project participants would be the Illinois Department of Conservation, U.S. Fish and Wildlife Service and the Corps of Engineers.

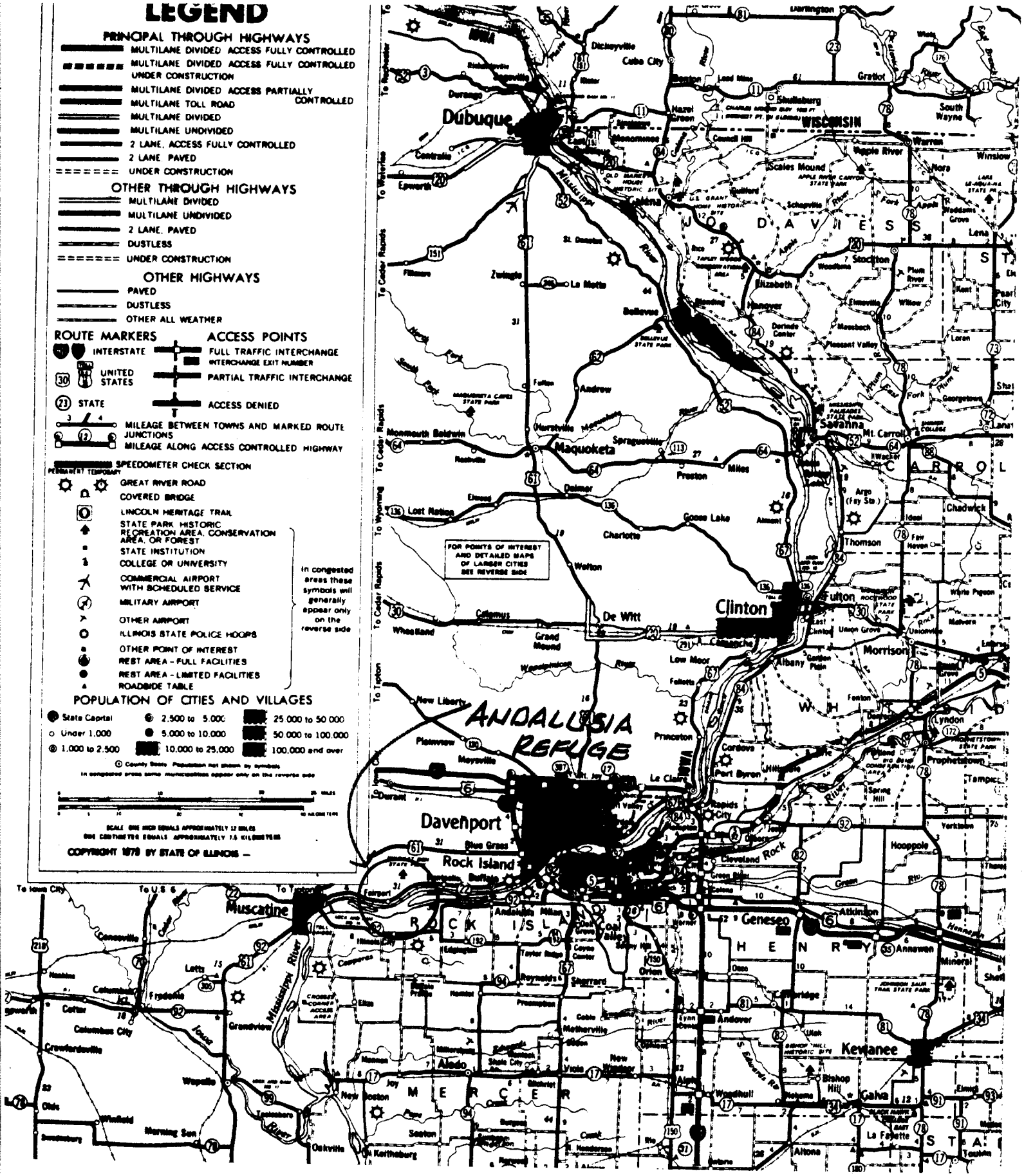
Project Schedule

It is estimated that the engineering and design phase of this project could be completed within 6 months following receipt of funds.

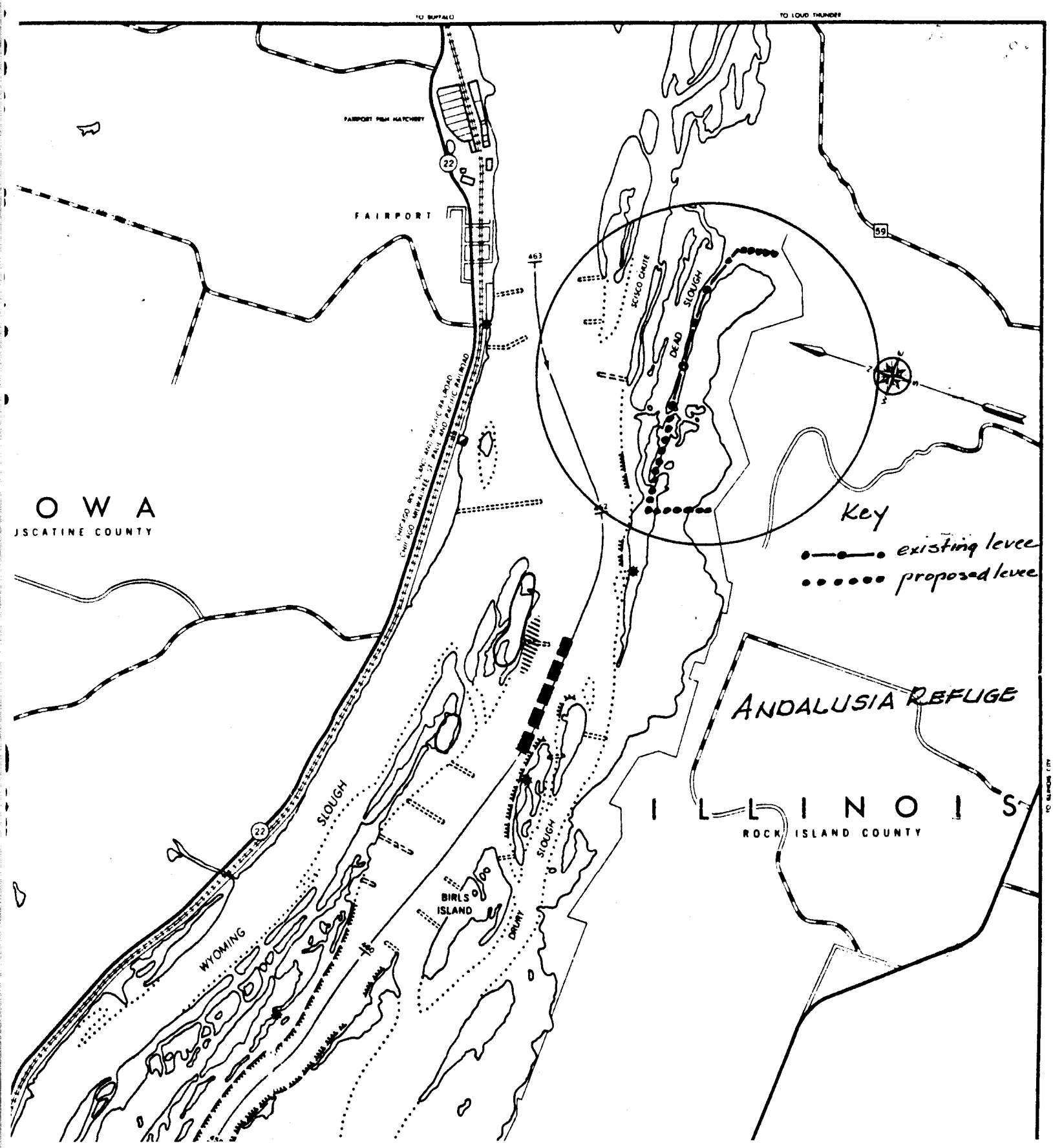
RECOMMENDATION

I recommend that the Secretary of the Army provide $43,000 for engineering and design for the Guttenberg Fish Pond project under the Upper Mississippi River System Environmental Management Program.

William C. Burns
Colonel, Corps of Engineers
District Engineer



Attachment 1 - Andalusia Refuge
Mississippi River, Illinois Department of Conservation
Proposed habitat enhancement project.



Attachment 2 - Andalusia Refuge
Proposed low levee extensions for shallow water habitat.

Illinois Department of Conservation
life and land together

LINCOLN TOWER PLAZA • 524 SOUTH SECOND STREET • SPRINGFIELD 62701-1787
CHICAGO OFFICE • ROOM 4-300 • 100 WEST RANDOLPH 60601
Michael B. Witte, Director • James C. Helfrich, Assistant Director

December 15, 1986

District Engineer
U.S. Army Engineer District, Rock Island
ATTN: Planning Division, PD-R
Clock Tower Building
P.O. Box 2004
Rock Island, Illinois 61204-2004

Dear Sirs:

Enclosed for your information is our revised Andalusia Refuge Project Scope for the Environmental Management Program. The changes made in this scope reflect the discussions our field staff had with your staff and the U.S. Fish & Wildlife Service staff about what we hope to accomplish at the refuge.

I have also included an estimated project requirement list we utilized to aid us in the development of this scope. Should you have any questions do not hesitate to call us.

Sincerely,

William R. Donels

William R. Donels
Landscape Architect
Division of Planning

BD:mib

cc: Gary McCandless
Bob Thornberry

UPPER MISSISSIPPI RIVER SYSTEM
ENVIRONMENTAL MANAGEMENT PROGRAM
GENERAL PLAN APPENDIX
FOR ENGINEERING AND DESIGN

Andalusia Refuge
Pool 16, Upper Mississippi River
Rock Island County, Illinois

INTRODUCTION

Project Authority

The 1985 Supplemental Appropriations Act (Public Law 99-88) provides authorization and appropriations for an environmental management program for the Upper Mississippi River system that includes fish and wildlife habitat rehabilitation and enhancement. The proposed project would be funded under this authorization.

Project Location

Within the Upper Mississippi Wildlife and Fish Refuge between river mile 462 and 463, immediately south of Dead Slough and north of Illinois City are 256 acres managed by the State of Illinois, Department of Conservation (see attachments 1 and 2).

Resource Problems and Opportunities

Presently, there are no low water control systems located in Pool 16. The construction of a low water control structure system would greatly enhance habitat and its management. The lack of shallow water habitat with submergent/emergent aquatic plants has adversely affected waterfowl, furbearer, and fisheries resources within this pool of the Mississippi River.

Proposed Solution

The proposed project would involve repair of an existing levee and construction of two additional low water levees about 7,200 feet long which would tie into high ground along the south edge of the impoundment to provide 130 acres of refuge area. It would include two 30-inch water control structures and some associated ditching that would accommodate portable pumps.

PROJECT REQUIREMENTS

Estimated Engineering and Design Cost

The estimated costs for the engineering and design project are:

Hydraulic Analysis	$ 2,500
Surveying	8,000
Engineering and Design	17,000
Procurement	2,500
Environmental Assessment	2,000
Coordination/Project Preparation	7,500
Total	$39,500

The engineering and design costs would be 100-percent Federal because the project is on the Upper Mississippi Wildlife and Fish Refuge and because the project's primary purpose is habitat improvement for migratory waterfowl.

The Illinois Department of Conservation has estimated project implementation costs to be $280,000. This cost estimate would be refined during the engineering and design phase.

Compliance with the National Environmental Policy Act of 1969 and other environmental laws and regulations would be documented during the engineering and design phase.

Project Participants

The primary project participants would be the Illinois Department of Conservation, U.S. Fish and Wildlife Service, and the Corps of Engineers.

Project Schedule

It is estimated that the engineering and design phase of this project could be completed within 6 months following receipt of funds.

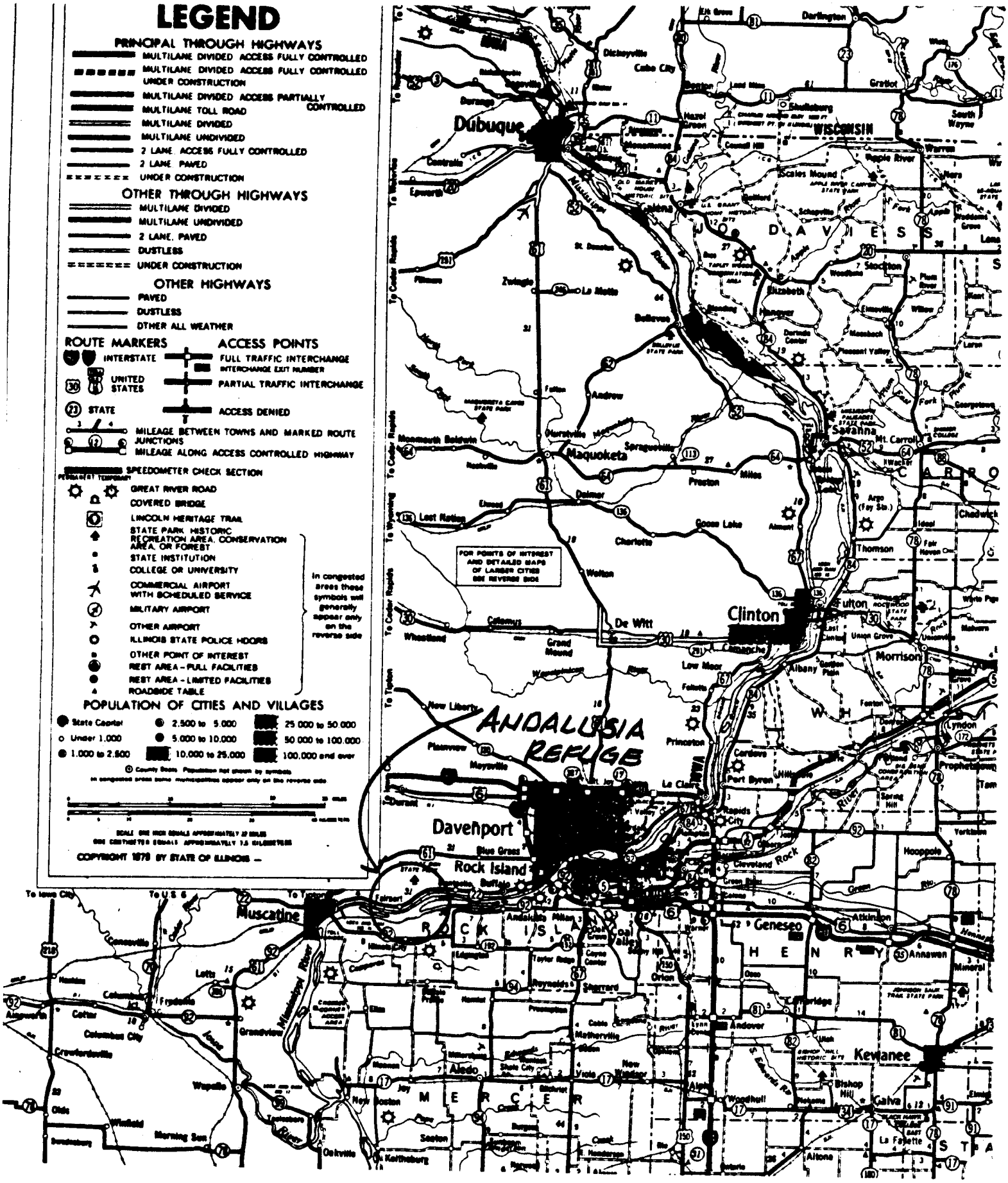
RECOMMENDATION

I recommend that the Secretary of the Army provide $39,500 for engineering and design for the Andalusia Refuge project under the Upper Mississippi River System Environmental Management Program.

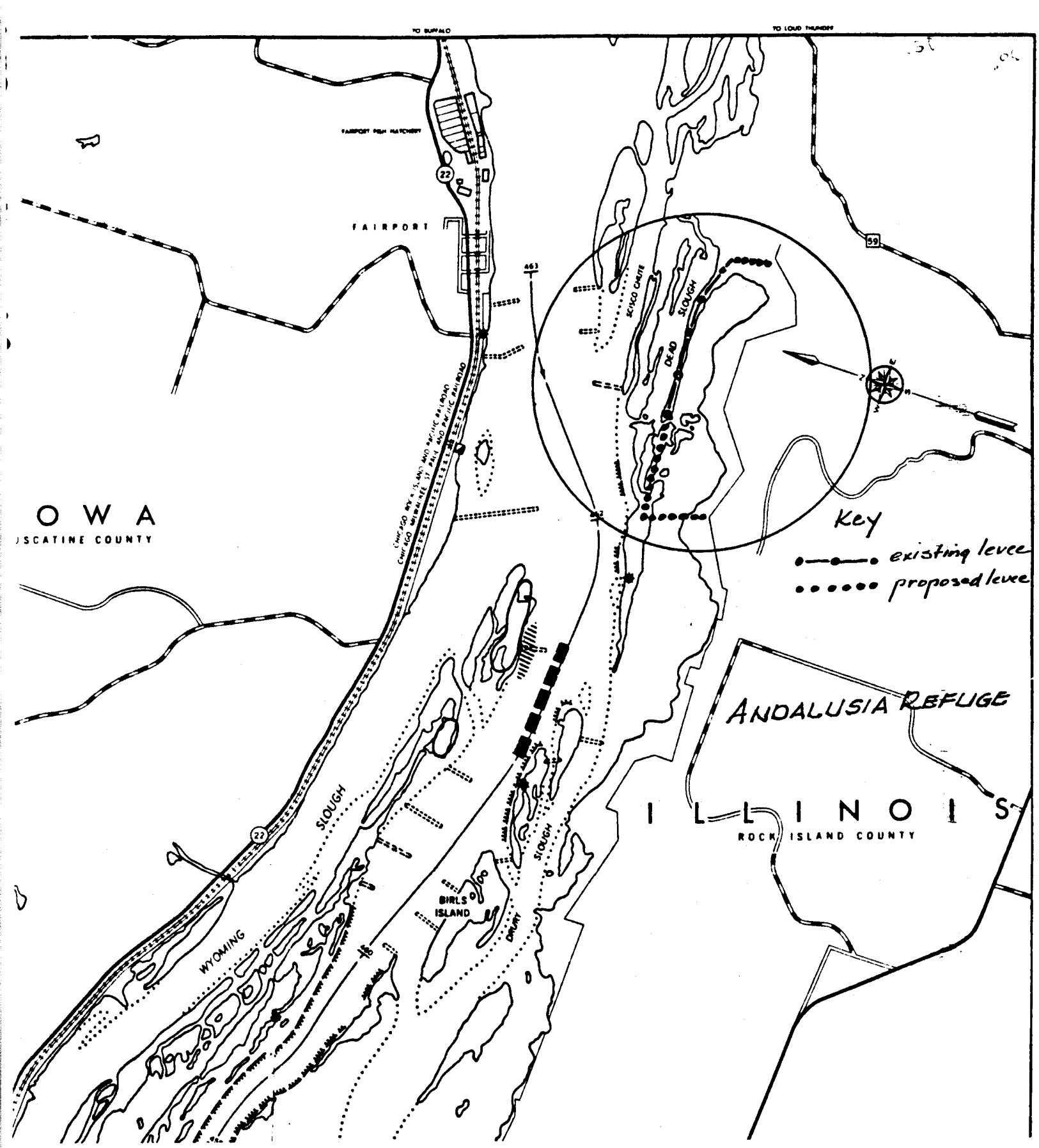
William C. Burns
Colonel, Corps of Engineers
District Engineer

ATTACHMENTS

1. General Area Map
2. Project Area Map



Attachment 1 - Andalusia Refuge
Mississippi River, Illinois Department of Conservation
Proposed habitat enhancement project.



Attachment 2 - Andalusia Refuge
Proposed low levee extensions for shallow water habitat.

DEPARTMENT OF THE ARMY
ROCK ISLAND DISTRICT, CORPS OF ENGINEERS
CLOCK TOWER BUILDING—P.O. BOX 2004
ROCK ISLAND, ILLINOIS 61204-2004

REPLY TO ATTENTION OF

September 16, 1987

Planning Division

Mr. John W. Comerio
Director
Office of Planning and Development
Illinois Department of Conservation
Lincoln Tower Plaza
524 South Second Street
Springfield, Illinois 62701-1787

Dear Mr. Comerio:

As you are aware, the Rock Island District is proceeding with design of the Upper Mississippi River System - Environmental Management Program (UMRS - EMP) project for habitat rehabilitation and enhancement at Andalusia Refuge, Illinois. At the time of the November 24, 1986, site visit, Mr. William Donels of your office noted that the State would have to seriously consider whether the operation and maintenance costs related to water level management for waterfowl would be supported by Illinois.

The major elements of the Andalusia Refuge project were set at a coordination meeting held at the District offices on March 4, 1987, with Illinois Department of Conservation, U.S. Fish and Wildlife Service, and Rock Island District personnel. At that time it was explicitly noted that an expression of the State's interest was critical for the District to proceed with design work and that such a statement would be forthcoming. This has been reiterated in subsequent telephone conversations between Mr. Donels and Mr. Andrew Bruzewicz of my staff, the District's EMP program manager.

It is essential that the District Receive written notice of the State's intentions before funds are expended on additional design work. As noted in the General Plan, dated January 1986, which describes the criteria for EMP projects, your support is a prerequisite for a viable project.

We would also appreciate written notification of the State's willingness to cost-share on the project at Rice Lake, Illinois. Unlike Andalusia Refuge, but like the

project for Peoria Lake for which we have received a letter of your intent, this project does not qualify for 100-percent Federal funding of design or construction.

Should you have any questions about this matter, please telephone Mr. Brzezwick at 309/788-6361, Ext. 203, or you may write to the following address:

District Engineer
U.S. Army Engineer District, Rock Island
ATTN: Planning Division
Clock Tower Building - P.O. Box 2004
Rock Island, Illinois 61204-2004

Sincerely,

ORIGINAL SIGNED BY

Dudley W. Hanson, P.E.
Chief, Planning Division

Copies Furnished:

Mr. Kent Frech
Director
Illinois Department of Conservation
Lincoln Tower Plaza
524 South Second Street
Springfield, Illinois 62701-1787

Mr. Donald Vennahme
Illinois Department of Transportation
Division of Water Resources
2300 South Dirksen Parkway
Springfield, Illinois 62764

Illinois Department of Conservation
life and land together

LINCOLN TOWER PLAZA • 524 SOUTH SECOND STREET • SPRINGFIELD 62701-
CHICAGO OFFICE • ROOM 4-300 • 100 WEST RANDOLPH 60601
MARK FRECH, DIRECTOR

October 8, 1987

Colonel Neil A. Smart
U.S. Army Engineer District, Rock Island
Clock Tower Building
P.O. Box 2004
Rock Island, Illinois 61204-2004

Attention: Dudley M. Hanson

Dear Colonel Smart:

With this letter of intent, I wish to commit the Department to operation and management of the Andalusia Refuge project, currently programmed in the Environmental Management Program for the Upper Mississippi River System and identified in the Second Annual Addendum and located on Upper Mississippi River Fish and Wildlife Refuge/General Plan land between river miles 462 and 463 of Pool 16, south of Dead Slough and north of Illinois City, in accordance with Section 906(e) of the 1986 WRDA.

The federal project includes upgrading a natural levee and constructing two additional low water levees, totaling about 7,200 feet in length, which tie into high ground along the south edge of the proposed impoundment. It also includes two 30-inch water control structures, a pump and associated ditching, dredging portions of Dead Slough for deep water fish habitat and rerouting a small tributary.

Upon final acceptance, the Department of Conservation will assume operation and management of the moist soil management area to provide submergent and emergent vegetation habitat for nesting, resting and shallow water feeding by migrating waterfowl. Departmental operation and management will include operation and maintenance of the pumps and water control structures, maintenance of the levee system, and general site management typical of a wildlife refuge.

My staff looks forward to working with your office in completing the project at a reasonable cost.

Sincerely,

Mark Frech

Mark Frech
Director

BD:mib

cc: Don Vonnahme
John Comerio

United States Department of the Interior

FISH AND WILDLIFE SERVICE
ROCK ISLAND FIELD OFFICE (ES)
1830 Second Avenue, Second Floor
Rock Island, Illinois 61201

IN REPLY REFER TO:
COM: 309/793-5800
FTS: 386-5800

August 4, 1988

Colonel Neil A. Smart
District Engineer
U.S. Army Engineer District
Rock Island
Clock Tower Building, P.O. Box 2004
Rock Island, Illinois 61204-2004

Dear Colonel Smart:

This constitutes our draft Fish and Wildlife Coordination Act report on the Andalusia Refuge Habitat Rehabilitation and Enhancement Project, a component of the Upper Mississippi River System Environmental Management Program (EMP). The EMP is authorized by the 1985 Supplemental Appropriation Act (Public Law 99-88) and Section 1103 of the Water Resources Development Act of 1986 (Public Law 99-662). The authority for this report is contained in Section 2 of the Fish and Wildlife Coordination Act of 1958 (Public Law 85-624).

PROJECT DESCRIPTION

The proposed project consists of construction of a levee approximately 8,600 feet in length and up to 110 feet in base width. The structure would provide protection from a 2-year flood event to 130 acres of the refuge, and would provide water level control to the protected area. A pump station with a capacity of 10 cubic feet per second would provide capability to increase or decrease water levels on the area in conjunction with a management plan. Approximately 110,000 cubic yards of material for the levee would be dredged from Dead Slough on the riverward side of the alinement. An additional 48,000 acres of material will also be obtained for the structure from the area to be protected. The dredging will result in 5,400 feet of channel in Dead Slough and 5,100 feet of channel in the protected portion of the refuge. The configuration of channel in the protected area will be designed to provide approximately nine acres of habitat divided among six or more islands, and to facilitate drawdown of water levels. Control structures in the levee would provide egress for fish trapped in the leveed area by flood events. The Dead Slough channel will be opened to Scisco Chute (thence to the main river) in order to provide ingress and egress for fish. The design of the above features is shown on plates 9 through 12 of the Corps' main report.

Andalusia Refuge is located on lands acquired by the Corps of Engineers (Corps) in the 1930's for the Mississippi River Navigation Project. By 1958 management of approximately 67,000 acres of the project between Muscatine, Iowa, and St. Louis, Missouri, had been transferred to the U. S. Fish and Wildlife Service (Service) by general plan and cooperative agreement. About 17,000 acres of these lands have been designated as the Mark Twain National Wildlife Refuge. The remaining 50,000 acres, including the Andalusia Refuge site, have been made available to the adjacent States for wildlife purposes.

The 320-acre Andalusia Refuge is located at approximate River Mile 462 in Pool 16, and is managed by the Illinois Department of Conservation under cooperative agreements with the Service and the Corps. The primary objective of the refuge is to provide feeding and resting habitat for waterfowl and other migratory birds. In that regard, the site is currently the only wildlife management area between the Princeton Wildlife Area at River Mile 507 (managed by the Iowa Department of Natural Resources), and the Louisa Unit of the Mark Twain National Wildlife Refuge at River Mile 410.

FISH AND WILDLIFE RESOURCES

The fisheries resources at Andalusia Refuge consist largely of catfish, carp and buffalo in Dead Slough. High water conditions in Pool 16 temporarily produces conditions that attract bass and other important species to the area. However, sedimentation over the years has reduced normal water depths in the slough to the point that the habitat is choked with duck weed, coontail and similar species. Summer low water levels often result in reduced dissolved oxygen content that can result in fish kills. The slough no longer has an opening to the river except during high water periods, resulting in fish being trapped in the backwater. Boat access for fishermen is also limited to high water periods.

The terrestrial resources on the refuge consist of 236 acres of cottonwoods, silver maple and willow surrounding approximately 150 acres of marsh landward of Dead Slough. The habitat values of the marsh have been greatly reduced over time by sediments accumulating from the uplands adjacent to the refuge. The value of the area to migratory waterfowl, particularly in the fall, is dependant upon the water levels in the Mississippi River. It is not uncommon for fall flood events to inundate a good crop of important food plants to depths that render the area unattractive to most waterfowl species. The excessively shallow summer water depths usually results in less than optimum nesting conditions for wood ducks, mallard and teal. Shallow water also contributes to nest predation during the breeding season, because predator access to nest sites is easier.

The timber on the refuge does not contain a large percentage of mast producers. However, there are areas consisting of older stands of cottonwood, maple and associated species that provide important nesting and feeding habitat for a variety of migratory birds. This type of habitat requires a long period of time to develop, and therefore protection of older timber stands is an important component of the Mark Twain National Wildlife Refuge Master Plan.

Bald eagles are the only federally listed threatened or endangered species that is known to utilize the refuge. The proposed project features should not affect that species.

PROBLEMS AND NEEDS

The current habitat values of Andalusia Refuge are limited by a lack of shallow water, an overabundance of emergent aquatic plant growth, and a lack of water control capability. The proposed project is an attempt to address those deficiencies and provide management flexibility. Sedimentation in Dead Slough has resulted in a greatly reduced fishery, and conditions that invite significant fish kills. The deepening of the slough and creation of an opening to Scisco Chute would address those problems.

Construction of the proposed levee could impact some of the older trees between Dead Slough and the marsh area landward of the levee alinement. Identification of this concern has resulted in the alinement presented in this draft, which minimizes the timber impact.

DISCUSSION

One of the major goals of the North American Waterfowl Plan is to maintain the habitat value of designated areas of international significance to waterfowl. The plan identifies the Upper Mississippi River as one of these specific areas of concern. The proposed project would provide water level management capability for Andalusia Refuge, and thus aid in restoration of the waterfowl values reduced by long-term sedimentation.

The current midcontinent drought conditions also illuminate the critical importance of the Upper Mississippi River to migratory birds when isolated wetland habitats are desiccated. The river pools will serve as a haven to the fall migration flights, and could provide the only significant resting habitat in the region for north bound birds in the spring if the drought persists for several years.

Although operated and maintained by the State, Andalusia Refuge is a component of the National Wildlife Refuge System. Actions that affect habitat on the refuge are subject to the compatibility requirements of the National Wildlife Refuge System Administration Act. Therefore, a compatibility statement will be prepared for inclusion in the Corps' final project report.

CONCLUSIONS AND RECOMMENDATIONS

The Andalusia Refuge Habitat Rehabilitation and Enhancement Project, as currently proposed, should restore and enhance fish and wildlife values on the refuge. The levee and pump station would provide management potential that is currently lacking at the site.

To expedite the approval and construction of this project we recommend:

1. that the final design, in particular the alinement of the levee, be closely coordinated with the Mark Twain National Wildlife Refuge staff to insure compatibility with the refuge master plan;

2. that a draft monitoring plan be developed prior to final project design, and;

3. that preconstruction monitoring of water quality and aquatic biota at the project site be initiated immediately;

We look forward to further coordination with your staff on this project.

Sincerely,

Charles P. Davis
Assistant Field Supervisor

cc: Mark Twain NWR
R.O. AE
R.O. AWR
IL DOC
IA DNR

Illinois Historic Preservation Agency

Old State Capitol • Springfield, Illinois 62701 • (217) 782-4836

217/785-4512

ROCK ISLAND COUNTY
Andalusia EMP Levee Alignment and Stream Realignment
Mississippi River
Andalusia Slough

September 7, 1988

James H. Blanchar, P.E.
Acting Chief, Operations Division
District Engineer, US Corps of Engineers
Rock Island District
Clock Tower Building-Post Office Box 2004
Rock Island, Illinois 61204-2004

Gentlemen:

Thank you for requesting comments from our office concerning the possible effects of the project referenced above on cultural resources. Our comments are required by Section 106 of the National Historic Preservation Act of 1966, as amended, and its implementing regulations, 36 CFR 800: "Protection of Historic Properties".

Our staff has reviewed the Archaeological Survey Short Report submitted by David G. Stanley, President, Bear Creek Archaeology, Inc. of Highlandville, Iowa for the proposed project referenced above.

The Phase I survey and assessment of the archaeological resources appear to be adequate. No archaeological material was recorded within the boundaries of the proposed Andalusia EMP Levee Alignment project area. Accordingly, we have determined, based upon this report, that no significant historic, architectural, and archaeological resources are located in the project area.

Please retain this letter in your files as evidence of compliance with Section 106 of the National Historic Preservation Act of 1966, as amended.

If you have any further questions, please contact Ms. Paula G. Cross, Staff Archaeologist, Illinois Historic Preservation Agency, Old State Capitol, Springfield, Illinois 62701, 217/785-4997.

Sincerely,

Theodore W. Hild
Deputy State Historic
Preservation Officer

TWH:PGC:bv
cc: Julia A. Hertenstein
Dudley Hanson, CoE, Planning Division
David Stanley

SECTION 404(B)(1) EVALUATION

DEPARTMENT OF THE ARMY
ROCK ISLAND DISTRICT, CORPS OF ENGINEERS
CLOCK TOWER BUILDING—P.O. BOX 2004
ROCK ISLAND, ILLINOIS 61204-2004

REPLY TO
ATTENTION OF:

CENCR-PD-E

CLEAN WATER ACT
SECTION 404(b)(1) EVALUATION

ANDALUSIA REFUGE HABITAT REHABILITATION AND ENHANCEMENT
POOL 16, UPPER MISSISSIPPI RIVER
ROCK ISLAND COUNTY, ILLINOIS

NOVEMBER 1988

CLEAN WATER ACT
SECTION 404(b)(1) EVALUATION

ANDALUSIA REFUGE HABITAT REHABILITATION AND ENHANCEMENT
POOL 16, UPPER MISSISSIPPI RIVER
ROCK ISLAND COUNTY, ILLINOIS

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CLEAN WATER ACT
SECTION 404(b)(1) EVALUATION

ANDALUSIA REFUGE HABITAT REHABILITATION AND ENHANCEMENT
POOL 16, UPPER MISSISSIPPI RIVER
ROCK ISLAND COUNTY, ILLINOIS

SECTION I - PROJECT DESCRIPTION

A. Location. The project is located in Rock Island County approximately 1 mile north of Illinois City on the Mississippi River, Pool 16, River Mile 462-463.

B. General Description. (See plate 2 and pages 16 through 21 of main report for details.) The proposed project calls for the construction of a 2-year event levee (elevation 550.8 MSL), 8,600 feet long, surrounding approximately 130 acres of Illinois Department of Conservation (IDOC) refuge land. Water levels within the leveed area will be controlled by pumping. Borrow material for the levee will be mechanically dredged from Dead Slough (approximately 110,000 cubic yards) and from the interior of the newly leveed Refuge (approximately 75,000 cubic yards).

An intermittent stream that now deposits sediment in the Refuge and Dead Slough will be rerouted to Scisco Chute. Approximately 11,700 cubic yards of mostly silt will be excavated to form a new channel 2,430 feet long, 3 feet deep, and 30 feet wide (bottom width). Material will be placed along the left bank of the channel and(or) placed in existing row crop land adjacent to the new channel. The mouth of Dead Slough also will be relocated approximately 1,800 feet upstream in Scisco Chute. Material will be placed on the levee alignment or possibly in nearby agricultural fields. A new access road to the proposed pump station will require filling of approximately 5,000 cubic yards into adjacent river areas.

Alternative out-of-floodplain (upland) fill sites are not feasible for this project. The intent of this project, which is waterfowl and fisheries habitat improvement, requires that it be located in aquatic and wetland habitats. The proposed levee alignment (fill site) minimizes the amount of fill to be placed in these environments.

C. Authority and Purpose. The 1985 Supplemental Appropriations Act (P.L. 99-88) and Section 1103 of the Water Resources Development Act of 1986 (P.L. 99-662) provide authorization and appropriations for an environmental management program on the Upper Mississippi River.

D. General Description of Fill Material. Test borings of the dredged material show it to be predominantly silts and clays.

E. Description of the Proposed Discharge Sites. The proposed discharge site, which is the new levee, occupies approximately 10 total acres. About 7.4 acres of the levee will replace existing bottomland forest. Material

excavated from the relocated channel will be placed on existing agricultural row crop land and(or) spread in adjacent bottomland forest. Plate 2 of the main report shows the location of the proposed discharge site. All material will be mechanically excavated (i.e., backhoe or clamshell).

SECTION II - FACTUAL DETERMINATIONS

A. Physical Substrate Determination.

1. Substrate Elevation and Slope. The proposed levee will raise the existing surface elevation along the alignment from 0 to 7 feet. The east-west levee segment will replace bottomland hardwood forest with an earthen levee. Although the substrate composition will remain much the same, the increased elevation and lack of canopy trees will promote growth of more upland plant types on the levee. The north-south levee tie-off will fill scrub/shrub and emergent/submergent wetland. Substrate composition will be similar, but the elevation will be increased to about 550.8 MSL. This tie-off section also will be armored with rock to prevent levee erosion when flooding occurs. Material excavated from the relocated drainage channel will be placed on adjacent woodland and cropland of similar substrate composition.

2. Sediment Type. The disposal site substrates consist primarily of bottomland soils composed predominantly of silts, clays, and organic soils.

3. Dredged/Fill Material Movement. All material will be placed by physical and mechanical methods that will ensure that it will not be displaced.

4. Physical Effects on Benthos. The composition of the dredged material is very similar to the disposal site substrate.

5. Action Taken to Minimize Impacts. The size and location of the levee minimize the loss of aquatic habitat. The north-south levee tie-off crosses the emergent-submergent wetland at its narrowest location. The levee right-of-way will be approximately 40 to 110 feet wide, minimizing the loss of bottomland forest.

B. Water Circulation, Fluctuation, and Salinity Determination.

1. Water.

a. Salinity - Not applicable.

b. Water Chemistry - The dredged material should not cause any direct change in water chemistry (i.e., pH). Indirectly, as a result of dredging, water quality in Dead Slough should improve.

c. Clarity - Water clarity within the leveed area will improve during flood events as long as the levee is not overtopped. The new levee will keep out sediment-laden floodwaters that previously flowed through the Refuge.

d. Color - No effect.

e. Odor - No effect.

f. Taste - No effect.

g. Dissolved Gas Levels - The amount of dissolved oxygen in Dead Slough should increase, particularly in fall and winter months.

h. Nutrients - The dredged material itself will not affect aquatic nutrients. The project will alter nutrient cycles in the Refuge (leveed area). The new levee will reduce nutrient exchange (import and export) to waters contiguous with the Mississippi River. This effect should be negligible.

i. Eutrophication - Indirectly the project should reverse eutrophication in Dead Slough.

2. Current Patterns and Circulation.

a. Current Patterns and Flow - The levee will prevent floodwaters up to the 2-year event (elevation 550.8) from entering the Refuge. The natural flow of water into and out of the Refuge from the downstream end will be blocked. A water control structure in the levee will now permit the flow of water between Dead Slough and the Refuge. The fill material will not affect current patterns and flows outside the Refuge and Dead Slough.

b. Velocity - The new levee may cause some minor increases in velocities since floodwaters that previously flowed through the Refuge will now be diverted.

c. Stratification - No effect anticipated.

d. Hydrologic Regime - The levee will divert flood flows, up to the 2-year event, from entering the Refuge.

3. Normal Water Level Fluctuation. The fill material will have a negligible effect on river stages.

C. Suspended Particulate/Turbidity Determinations.

1. Suspended particulates and turbidity will increase in Dead Slough and the Refuge during dredging and disposal. Some temporary elevation of these parameters also will occur in the Mississippi River main channel when the mouth of Dead Slough is dredged. These suspended particulates and increased turbidity will be predominantly clays and silts.

2. Effects on Chemical and Physical Properties of the Water Column.

a. Light Penetration - Temporary reduction during dredging, but no permanent adverse effects will result.

b. Dissolved Oxygen - The increased turbidity during dredging may cause temporary and localized reductions in D.O.

c. Toxic Metals and Organics - Results of bulk sediment analyses indicate that all organic contaminants were present in concentrations less than their respective detection limits. Toxic metals did exhibit measurable levels for several parameters, however, only nickel and zinc fell in the "moderately polluted" category as established by U.S. EPA Region V draft sediment criteria. Elutriate test results indicate that toxic metal and organic contaminants were quite low and, in most cases, less than their respective detection limits.

d. Pathogens - No effect.

e. Aesthetics - No effect.

3. Effects on Biota.

a. Primary Production - Some primary production from bottomland forest and wetland will be lost due to levee construction. Overall, however, primary productivity within the leveed refuge will increase.

b. Suspension/Filter Feeders - No effect.

c. Sight Feeders - Temporary and localized increases in turbidity may cause some sight-feeding fishes to move to adjacent areas. Effects will be negligible.

D. Contaminant Determinations. Results of ambient water and elutriate tests were compared to Illinois State Water Quality General Use standards. The concentration of ammonia nitrogen in two elutriate samples exceeded the standard of 1.5 mg/l. Also, the concentrations of copper in one elutriate sample and lead in the ambient water exceeded their respective standards of 0.05 and 0.10 mg/l. Results of bulk sediment analyses indicate that ammonia is the only pollutant to occur in concentrations in excess of nonpolluted category based on Interim Guidelines for the Pollutional Classification of Great Lakes Harbor Sediments.

E. Aquatic Ecosystem and Organism Determinations.

1. Effects on Plankton - No effect.

2. Effects on Nekton - There will be little or no direct adverse impacts from fill placement on nektonic organisms such as fish. Indirectly the fisheries of Dead Slough will be greatly improved due to the dredging. Please refer to the Environmental Assessment for a detailed discussion.

3. Effects on Benthos - Adverse impacts on benthos will be negligible. The deepening of Dead Slough and leveeing of the Refuge could cause changes in benthic species diversity locally.

4. Effects on Aquatic Food Web - The proposed fill will inhibit the upper end of the Refuge wetland from freely exchanging nutrients, water, etc. with the main river. Nutrients that otherwise would be transported to other downstream locations during floods will most likely stay within the leveed area. Any effects beyond the Refuge will be negligible.

5. Effects on Special Aquatic Sites.

a. Sanctuaries and Refuges - The proposed discharge will occur in a State-managed waterfowl refuge. At present, the Refuge has no water level management capability. The project will allow biologists to manipulate water levels, thus greatly improving waterfowl food production in the Refuge. The excavation of levee borrow material from Dead Slough will rejuvenate its fishery habitat, which at present acts as more of a detriment. (At low water stages, fish become trapped in the slough with no way of escape.)

b. Wetlands - The entire project area consists of a wetland complex comprised of several classes and subclasses of Palustrine wetlands, such as aquatic bed (rooted vascular, floating vascular, unconsolidated bottom (mud), emergent (persistent), and forested (broadleaf deciduous).

Several of these wetland types will be affected directly and indirectly by the fill. Approximately 18 acres of forested, aquatic bed, and emergent wetland will be filled or cleared. The seasonal water regime of 130 acres of emergent and aquatic bed wetland will become artificially controlled. This artificial water level control will likely cause vegetation diversity to decrease. Annual species such as smartweed (Polygonum spp.) are likely to increase in abundance. Scrub/shrub species around the levee perimeter, such as willow, could decrease in abundance depending upon future water level management practices. The possible decrease in plant diversity and loss of the natural water regime will be exchanged for improved waterfowl feeding and resting habitat.

c. Mudflats - Vegetated mudflats may increase within the leveed Refuge on account of manipulated water levels.

d. Vegetated Shallows - See discussion on wetlands.

e. Coral Reefs - Not applicable.

f. Riffle and Pool Complexes - No effect.

6. Threatened and Endangered Species. The American bald eagle is the only federally endangered or threatened species known to use the project area. Migrating eagles occasionally use the Refuge area during late fall and early winter when ice is not present. During the colder winter months of January

and February, eagle use is minimal or nonexistent. The project area does not provide any critical life requirements for wintering eagles. The proposed fill will have no effect on eagles.

There are no known State-listed endangered or threatened species present on the project site.

7. Other Wildlife - The loss of mast trees along the upland portion of levee alignment will reduce the amount of food available to such wildlife as wood ducks, deer, and squirrel. The levee alignment has been moved riverward into Dead Slough in order to reduce the loss of trees.

F. Proposed Disposal Site Determinations.

1. Mixing Zone Determination - Negligible effects.

2. Determination of Compliance with Applicable Water Quality Standards - Water quality standards for Illinois are discussed in Section II, C.2.c. Test results indicate that ammonia nitrogen is the most likely water quality standard which may be violated by the project activity. However, the proposed dredging and disposal methods for material containing all contaminants are expected to minimize contaminant reintroduction to the water column.

3. Potential Effects on Human Use Characteristics.

a. Municipal and Private Water Supply - No effect.

b. Recreational and Commercial Fisheries - Although there will be 130 acres of wetland (used by fish during high water) isolated due to levee construction, the excavation of Dead Slough will create an excellent backwater fish habitat valuable to both recreational and commercial fishermen.

c. Water Related Recreation - The project will create recreational fishing opportunities in Dead Slough where none currently exist. The improved ability of the Refuge to provide quality migratory waterfowl habitat may improve waterfowl hunting opportunities adjacent to the Refuge.

d. Aesthetics - Construction and maintenance of the levee will detract from the natural undisturbed setting that now exists. Increased waterfowl use of the Refuge may improve aesthetics relating to wildlife viewing.

e. Parks, National and Historical Monuments, National Seashores, Wilderness Areas, Research Sites, and Similar Preserves - No effect.

G. Determination of Cumulative Effects on the Aquatic Ecosystem. No cumulative effects are anticipated, since there will be no future disposal actions (exclusive of project maintenance and repair) after project completion.

H. Determination of Secondary Effects on the Aquatic Ecosystem. No adverse secondary effects will occur to the aquatic ecosystem.

SECTION III - FINDINGS OF COMPLIANCE OR NONCOMPLIANCE WITH THE RESTRICTIONS ON DISCHARGE

A. Adaptation of the Section 404(b)(1) Guidelines to this Evaluation. No significant adaptation of the 404(b)(1) guidelines was made in this evaluation.

B. Evaluation of Availability of Practicable Alternatives to the Proposed Discharge Site Which Would Have Less Adverse Impact on the Aquatic Ecosystem. Several alternative levee alignments were studied. The selected alignment minimizes the amount of fill in aquatic and wetland sites. Alternative, out-of-floodplain project locations are not practicable by the very nature of this project. Projects designed to manipulate natural water level fluctuations for the benefit of wildlife must be located in aquatic/wetland environments. There are no practicable alternatives.

C. Compliance With Applicable State Water Quality Standards. Permits, certification, or waiver of certification under Section 401 of the Clean Water Act will be obtained before construction begins. The project will thus be in compliance with water quality requirements of the State of Illinois.

D. Compliance With Applicable Toxic Effluent Standard or Prohibition Under Section 307 of the Clean Water Act. The disposal will not violate any toxic effluent standards.

E. Compliance With Endangered Species Act, as Amended. The project will have no effect on any federally endangered or threatened species.

F. Evaluation of Extent of Degradation of the Waters of the United States. The proposed project will not affect any municipal or private water supplies. Recreational and commercial fisheries will benefit from the project by the creation of fish habitat in Dead Slough. The project will have no adverse effects on plankton, shellfish, or special aquatic sites. Some wildlife species will suffer minor adverse effects from the loss of some mast-producing trees along the levee alignment. There will be no significant adverse effects to aquatic-dependent wildlife, ecosystem diversity, productivity, and stability. The habitat improvement from this project should benefit recreational opportunities in Pool 16, as well as economics. There will be some loss of aesthetic values due to the construction of the levee.

G. Appropriate and Practicable Steps Taken to Minimize Potential Adverse Impacts of the Discharge on the Aquatic Ecosystem. The selected levee alignment will minimize the amount of aquatic and wetland habitat filled.

H. On the basis of the guidelines, the proposed disposal site for the discharge of dredged material is specified as complying with the requirements of these guidelines with the inclusion of appropriate and practical conditions to minimize pollution or adverse effects to the affected aquatic ecosystem.

_____
Date

Neil A. Smart
Colonel, U.S. Army
District Engineer

DRAFT LOCAL COOPERATION AGREEMENT

APPENDIX C

D R A F T

LOCAL COOPERATION AGREEMENT
BETWEEN
THE DEPARTMENT OF THE ARMY
AND
THE ILLINOIS DEPARTMENT OF CONSERVATION
FOR CONSTRUCTION OF THE
ANDALUSIA REFUGE HABITAT ENHANCEMENT PROJECT
ON THE MISSISSIPPI RIVER
AT ANDALUSIA, ILLINOIS

THIS AGREEMENT, entered into this _____ day of _____, 1988, by and between the DEPARTMENT OF THE ARMY (hereinafter referred to as the "Government"), acting by and through the Assistant Secretary of the Army (Civil Works), and the STATE OF ILLINOIS (hereinafter referred to as the "State"), acting by and through the Illinois Department of Conservation,

WITNESSETH, that

WHEREAS, the Andalusia Refuge Habitat Enhancement Project (hereinafter referred to as the "Project") was approved under the terms of the Upper Mississippi River System Environmental Management Program, as authorized by the Water Resources Development Act of 1986 (Public Law 99-662); and

WHEREAS, the Water Resources Development Act of 1986, Public Law 99-662, specifies the cost-sharing requirements applicable to the Project; and

WHEREAS, title to all of the lands required for the Project is vested in the United States and is under the Control of the U.S. Army Corps of Engineers; and

WHEREAS, said land is managed by the Illinois Department of Conservation as a national wildlife refuge within the meaning of Section 906(e)(3) of Public Law 99-662; and

WHEREAS, the Illinois Department of Conservation has the authority and capability to furnish the cooperation hereinafter set forth under Section 6361 of Ch. 27, Ill. Rev. Stat. 1987, and is willing to participate in accordance with the terms of this Agreement;

NOW, THEREFORE, the parties agree as follows:

ARTICLE 1 - DEFINITIONS

For purposes of this Agreement:

a. The term "Project" shall mean construction of a low levee approximately seven to nine feet high, with a riprapped overflow weir section, along the riverside edge of the Refuge and tying into higher ground upstream and downstream; a pump station with two submersible pumps, trash racks, and a water control structure with a 36-inch diameter concrete conduit and a sluice gate; access roads to the pump station and levee system; provision of a source of overhead electrical power; excavation in Dead Slough and of a water access from Scisco Chute to Dead Slough; excavation of drainage channels within the Refuge, including excavation to create an island; excavation of a diversion drainage ditch to reroute the creek emptying into the upper end of the Refuge into Scisco Chute; and an unsurfaced maintenance road for the diversion ditch.

b. The term "total project costs" shall mean all costs incurred by the Government directly related to construction of the Project. Such costs shall include, but not necessarily be limited to, actual construction costs, costs of applicable engineering and design, continuing planning and engineering costs incurred after October 1,

1985, supervision and administration costs, costs of project construction contract dispute settlements or awards, and any costs associated with providing for the use of Government-owned lands, but shall not include any costs for operation, maintenance, rehabilitation, replacement, or betterments.

c. The term "period of construction" shall mean the time from the advertisement of the first Government construction contract to the time of acceptance of the Project by the Contracting Officer.

d. The term "Contracting Officer" shall mean the Commander of the U.S. Army Engineer District, Rock Island, or his designee.

ARTICLE II - OBLIGATIONS OF THE PARTIES

a. The Government, subject to and using funds appropriated by the Congress, shall expeditiously construct the Project applying those procedures usually followed or applied in Federal projects, pursuant to Federal laws, regulations, and policies. The State shall be afforded the opportunity to review and comment on all contracts, including relevant plans and specifications, prior to the issuance of invitations for bids. The State also shall be afforded the opportunity to review and comment on all modifications and change orders prior to the issuance to the contractor of a Notice to Proceed. The Government will consider the views of the State, but award of the contracts and performance of the work thereunder shall be exclusively within the control of the Government.

b. When the Government determines that the Project, or functional element thereof, is complete, the Government shall turn the Project or element over to the State, which shall accept the Project or element and be solely responsible, subject to the provisions of Article

XIII of this Agreement for operating, maintaining, replacing, and rehabilitating the Project or element in accordance with ARTICLE VIII hereof.

c. No Federal funds may be used for the non-Federal share of project costs unless specifically authorized for that purpose.

ARTICLE III - CONSTRUCTION PHASING AND MANAGEMENT

a. To provide for consistent and effective communication between the State and the Government during the term of construction, the State and the Government shall appoint representatives to coordinate on scheduling, plans, specifications, modifications, contract costs, and other matters relating to construction of the Project.

b. The representatives appointed as provided above shall meet as necessary during the term of Project construction and shall make such recommendations as they deem warranted to the Contracting Officer.

c. The Contracting Officer shall consider the recommendations of the representatives in all matters relating to the Project, but the Contracting Officer, having ultimate responsibility for construction of the Project, has complete discretion to accept, reject, or modify the recommendations.

ARTICLE IV - DISPUTES

Before any party to this Agreement may bring suit in any court concerning an issue relating to this Agreement, such party must first seek in good faith to resolve the issue through negotiation or other forms of nonbinding alternative dispute resolution mutually acceptable to the parties.

ARTICLE V - OPERATION, MAINTENANCE, AND REHABILITATION

a. After the Project is turned over by the Government, the State, subject to the provisions of Article XIII of this Agreement,

shall operate, maintain, replace, and rehabilitate the Project, or functional element thereof, in accordance with regulations or directions prescribed by the Government.

b. The State currently has a right to enter upon the lands for wildlife conservation and management, in accordance with the General Plan for Use of the Project Land and Water Areas for Wildlife Conservation and Management, Mississippi River Between the Missouri River and Minneapolis, Minnesota, State of Illinois, executed by the Department of the Army on 19 January 1961; and in accordance with the Cooperative Agreement between the Department of the Army and the Department of Interior, Bureau of Sport Fisheries and Wildlife, dated 14 February 1963. This Agreement shall be interpreted in conjunction with said prior agreements and is not considered to be violative of the terms of said agreements.

c. If inspection shows that the State for any reason is failing to fulfill its obligations under this Agreement without receiving prior written approval from the Government, the Government shall send a written notice to the State. If the State persists in such failure for 30 calendar days after receipt of this notice, then the Government shall have a right to enter, at reasonable times and in a reasonable manner, upon Project lands for the purpose of completing, operating, repairing, maintaining, replacing, or rehabilitating the Project. No completion, operation, repair, maintenance, replacement, or rehabilitation by the Government shall operate to relieve the State of responsibility to meet its obligations as set forth in this Agreement, or to preclude the Government from pursuing any other remedy at

law or equity to assure faithful performance pursuant to this Agreement.

ARTICLE VI - RELEASE OF CLAIMS

The State shall hold and save the Government free from all damages arising from the construction, operation, maintenance, replacement, and rehabilitation of the Project, except for damages due to the fault or negligence of the Government or its contractors.

ARTICLE VII - MAINTENANCE OF RECORDS

The Government and the State shall keep books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to this Agreement to the extent and in such detail as shall properly reflect total project costs. The Government and the State shall maintain such books, records, documents, and other evidence for a minimum of three years after completion of construction of the Project and resolution of all claims arising therefrom, and shall make available at their offices at reasonable times, such books, records, documents, and other evidence for inspection and audit by authorized representatives of the parties to this Agreement.

ARTICLE VIII - FEDERAL AND STATE LAWS

In acting under its rights and obligations hereunder, the State agrees to comply with all applicable Federal and State laws and regulations, including Section 601 of Title VI of the Civil Rights Act of 1964 (Public Law 88-352) and Department of Defense Directive 5500.11 issued pursuant thereto and published in Part 300 of Title 32, Code of Federal Regulations, as well as Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army."

ARTICLE IX - RELATIONSHIP OF PARTIES

The parties to this Agreement act in an independent capacity in the performance of their respective functions under this Agreement, and neither party is to be considered the officer, agent or employee of the other.

ARTICLE X - OFFICIALS NOT TO BENEFIT

No member of or delegate to the Congress, or Resident Commissioner of the United States, shall be admitted to any share or part of this Agreement, or to any benefit that may arise therefrom.

ARTICLE XI - COVENANT AGAINST CONTINGENT FEES

The State warrants that no person or selling agency has been employed or retained to solicit or secure this Agreement upon agreement or understanding for a commission, percentage, brokerage, or contingent fee, excepting bona fide employees of bona fide established commercial or selling agencies maintained by the State for the purpose of securing business. For breach or violation of this warranty, the Government shall have the right to annul this Agreement without liability, or, in its discretion, to add to this Agreement or consideration, or otherwise recover, the full amount of such commission, percentage, brokerage, or contingent fee.

ARTICLE XII - TERMINATION OR SUSPENSION

If the Government fails to receive annual appropriations in amounts sufficient to meet Project expenditures for the then-current or upcoming fiscal year, the Government shall so notify the State. After 60 days either party may elect without penalty to terminate this Agreement or to suspend performance thereunder, and the parties shall conclude their activities relating to the Project.

ARTICLE XIII - OBLIGATION OF FUTURE APPROPRIATIONS

Nothing in this Agreement shall constitute or be deemed to constitute an obligation of future appropriations by the legislature of the State of Illinois, and all obligations of the State shall cease if the legislature fails to appropriate the funds necessary to meet the State's obligation pursuant to this obligation.

ARTICLE XIV - NOTICES

a. All notices, requests, demands, and other communications required or permitted to be given under this Agreement shall be deemed to have been duly given if in writing and delivered personally, given by prepaid telegram, or mailed by first-class (postage prepaid), registered, or certified mail, as follows:

If to the State:
Director
Illinois Department of Conservation
Lincoln Tower Plaza
524 South 2nd Street
Springfield, Illinois 62701-1787

If to the Government:
District Engineer
U.S. Army Engineer District, Rock Island
Clock Tower Building, PO Box 2004
Rock Island, Illinois 61204-2004

b. A party may change the address to which such communications are to be directed by giving written notice to the other in the manner provided in this section.

c. Any notice, request, demand, or other communication made pursuant to this Article shall be deemed to have been received by the addressee at such time as it is personally delivered or on the third business day after it is mailed, as the case may be.

ARTICLE XV - CONFIDENTIALITY

To the extent permitted by the law governing each party, the parties agree to maintain the confidentiality of exchanged information when requested to do so by the providing party.

IN WITNESS WHEREOF, the parties hereto have executed this Agreement as of the day and year first above written.

THE DEPARTMENT OF THE ARMY	STATE OF ILLINOIS DEPARTMENT OF CONSERVATION
By: _____ ROBERT W. PAGE Assistant Secretary of the Army (Civil Works)	By: _____ Title: _____
DATE: _____	DATE: _____

CERTIFICATE OF AUTHORITY

I, _____, do hereby certify that I am the Attorney General of the State of Illinois, that the State is a legally constituted public body with full authority and legal capability to perform the terms of the Agreement between the Department of the Army and the Illinois Department of Conservation for local cooperation in connection with a project for the enhancement of habitat at the Andalusia Refuge, and to pay damages, if necessary, in the event of its failure to perform, in accordance with Section 221 of Public Law 91-611, as amended, and that the person who has executed the Agreement on behalf of the Illinois Department of Conservation has acted within his statutory authority.

IN WITNESS WHEREOF, I have made and executed this Certificate this _____ day of _____, 198_____.

_____

Attorney General for the State of Illinois

APPENDIX D

DISTRIBUTION LIST

DISTRIBUTION LIST FOR

UPPER MISSISSIPPI RIVER SYSTEM
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DEFINITE PROJECT REPORT
ANDALUSIA REFUGE
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FEDERAL EMERGENCY MANAGEMENT ADMIN, 500 C STREET SW ROOM 713, WASHINGTON DC 20472	
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US FISH & WILDLIFE SERVICE, ATTN CHUCK DAVIS/LEROY SOWL 1830 SECOND AVENUE, ROCK ISLAND IL 61201	
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US FISH & WILDLIFE SERVICE, NORTH CENTRAL REGL OFFICE ATTN CHUCK GIBBONS, FEDERAL BLDG-FORT SNELLING TWIN CITIES MN 55111	
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OFFICE OF THE GOVERNOR, ATTN: TOM BERKSHIRE STATE OF ILLINOIS, SPRINGFIELD, IL 62706	
HONORABLE JAMES R THOMPSON, GOVERNOR OF ILLINOIS STATE CAPITOL, SPRINGFIELD IL 62706	
DIRECTOR, BUREAU OF SOIL & WATER CONS IL DEPT OF AGRICULTURE, EMERSON BLDG-IL ST FAIRGROUNDS SPRINGFIELD IL 62706	
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MR BILL JONES, ILLINOIS DEPT OF CONSERVATION LINCOLN TOWER PLAZA, 524 SOUTH 2ND STREET SPRINGFIELD IL 62706	
MR DONALD VONNAHME - DIRECTOR, DIVISION OF WATER RESOURCES IL DEPARTMENT OF TRANSPORTATION, 2300 SOUTH DIRKSEN PARKWAY SPRINGFIELD IL 62764	3

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HONORABLE M BOB DEJAEGHER, ILLINOIS REPRESENTATIVE 209 19TH STREET, EAST MOLINE IL 61244	
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ATTN MICHAEL J RUEHRERS, 11712 78TH AVE W
TAYLOR RIDGE IL 61284

MRS. JANE JOHNSON, PRESIDENT
ILLINOIS COUNCIL OF WATERSHEDS, R.R. 2, BOX 50
GILSON, IL 61436

EMILY H. SMITH, RI CNTY LEAGUE OF WOMEN VOTERS
4421 42ND AVE., ROCK ISLAND, IL 61201

BI-STATE BASS CLUB, 828 BELMONT AVE
DAVENPORT IA 52802

QUAD CITY BASS CLUB, 4329 TELEGRAPH ROAD
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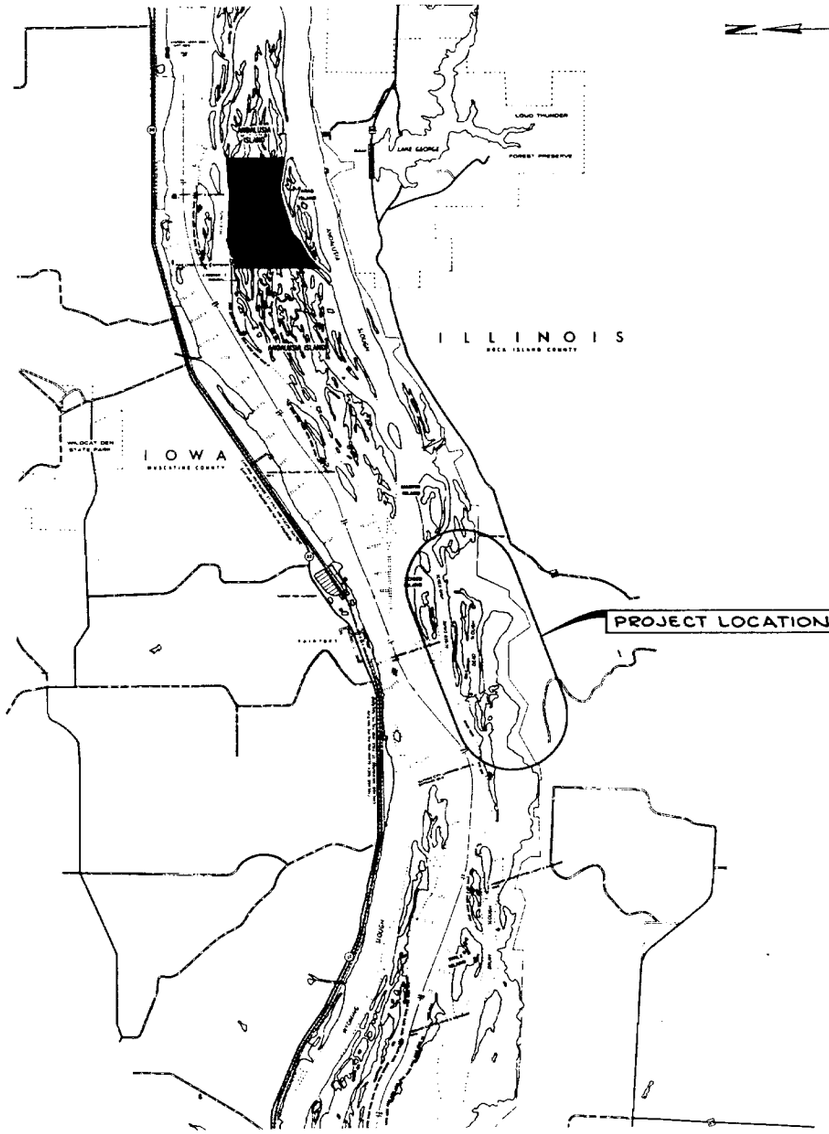
CENCR-ED-H	CENCR-OD-MC
CENCR-ED-HH	CENCR-CD
CENCR-ED-HQ	CENCR-IM-C (3)
	CENCR-PA



LOCATION MAP

STATUTE MILES 0 1 2

INDEX	
PLATE NO.	DESCRIPTION
1	LOCATION MAP
2	RECOMMENDED PLAN
3	ALTERNATIVE PLANS
4	ADJACENT WATERSHEDS
5	HYDRAULIC DATA I
6	HYDRAULIC DATA II
7	BORING LOGS
8	PLAN STA. 12+21.59C to STA. 11+00
9	PLAN STA. 11+00 to STA. 20+00
10	PLAN STA. 20+00 to STA. 45+40
11	PLAN STA. 43+40 to STA. 18+00CE
12	PLAN STA. 18+00CE to STA. 19+00W & to STA 34+50CE
13	PLAN STA. 19+00W to STA. 33+24.65W
14	PLAN STA. 34+50 CE to STA. 0+00F
15	PROFILES I
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20	PUMP STATION
21	WATER CONTROL STRUCTURE
22	ELECTRICAL ONE-LINE DIAGRAM
23	SEDIMENTATION AND MONITORING PLAN
24	SEDIMENT RANGES A THROUGH K
25	SEDIMENT RANGES L THROUGH P

VICINITY MAP

25 0 25 50 75

SCALE IN MILES

SIGNATURES AFFIXED BELOW INDICATE OFFICIAL RECOMMENDATION AND APPROVAL OF ALL DRAWINGS IN THIS SET AS INDICATED ON EACH INDIVIDUAL TITLE BLOCK

Prepared by:
U.S. ARMY ENGINEER DISTRICT, ROCK ISLAND
Submitted by:
CHIEF, DESIGN BR.
CHIEF, HYDRAULICS BR.
CHIEF, GEOTECHNICAL BR.
Recommended by:
CHIEF, ENGINEERING DIV.
Approved by:
COL, CORPS OF ENGINEERS Date:

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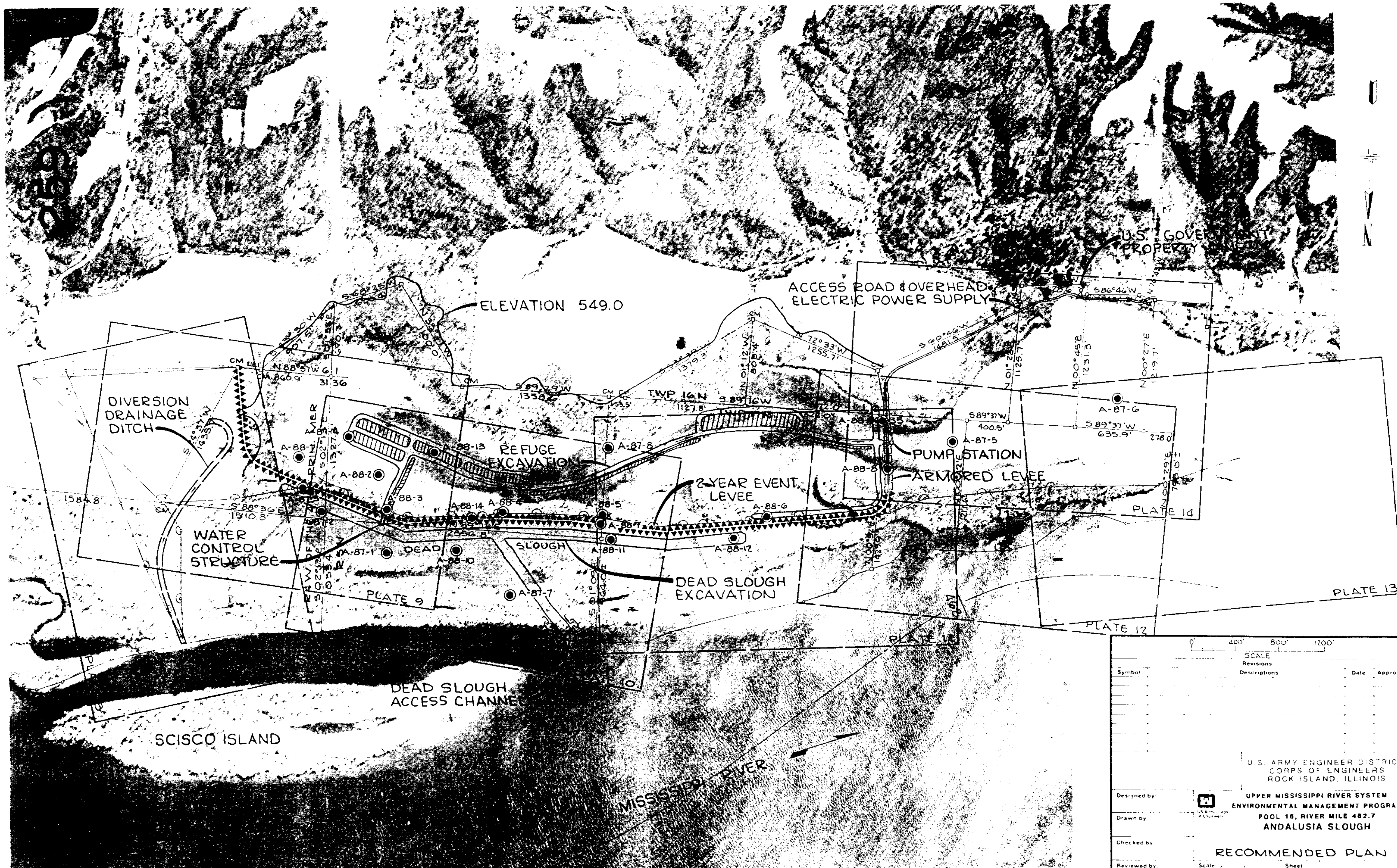
US Army Corps of Engineers

UPPER MISSISSIPPI RIVER SYSTEM
ENVIRONMENTAL MANAGEMENT PROGRAM
POOL 16, RIVER MILE 482.7
ANDALUSIA SLOUGH
LOCATION MAP

Scale: As shown
Date:
Drawing Code:
Sheet reference number:
Sheet _ of _

PLATE 1



0' 400' 800' 1200'
SCALE

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ANDALUSIA SLOUGH

RECOMMENDED PLAN

Scale: As shown
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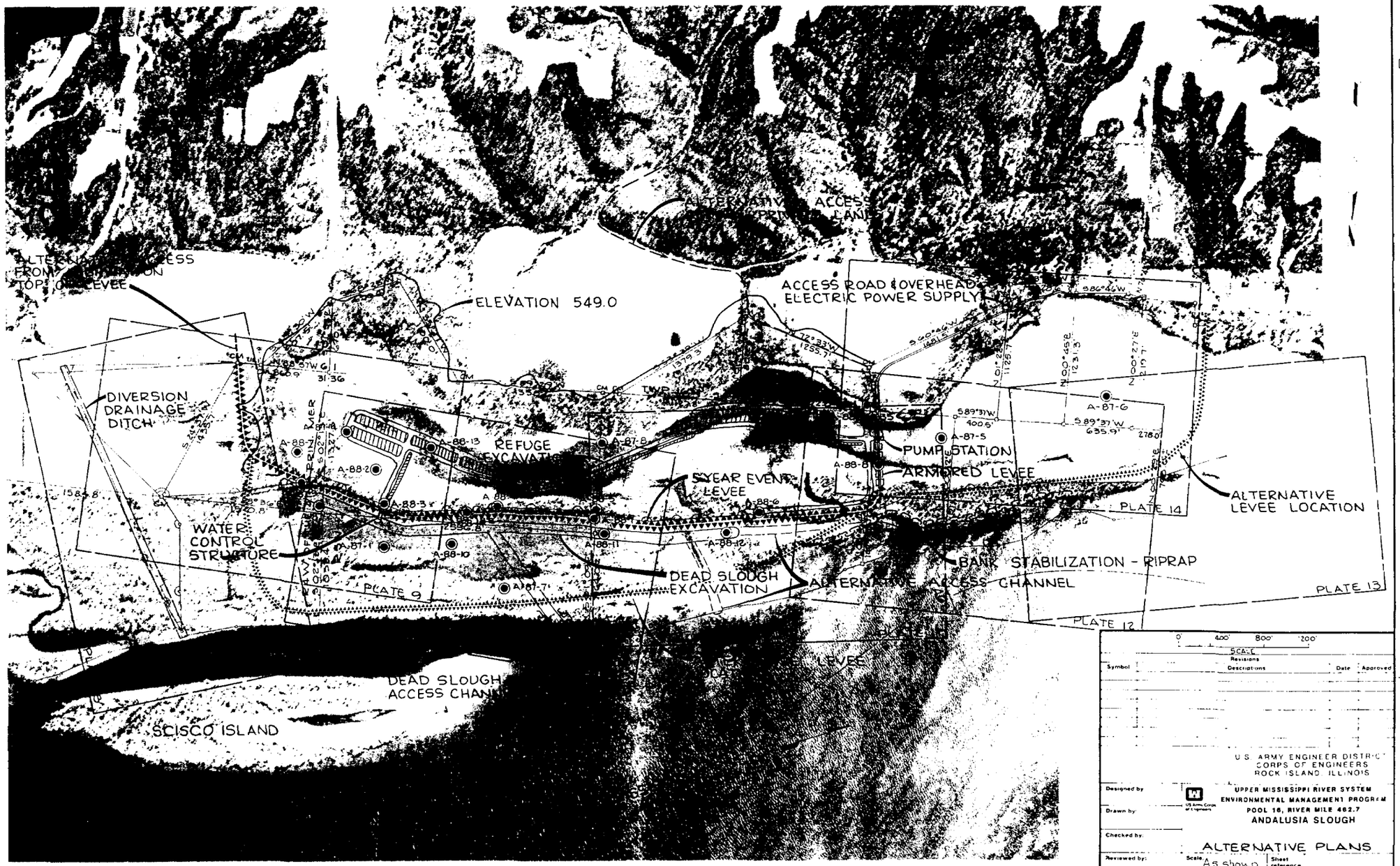
PLATE 2


ELEVATION 549.0
ACCESS ROAD & OVERHEAD ELECTRIC POWER SUPPLY
DIVERSION DRAINAGE DITCH
REFUGE EXCAVATION
PUMP STATION
ARMORED LEVEE
5 YEAR EVENT LEVEE
ALTERNATIVE LEVEE LOCATION
WATER CONTROL STRUCTURE
DEAD SLOUGH EXCAVATION
BANK STABILIZATION - RIPRAP
ALTERNATIVE ACCESS CHANNEL
DEAD SLOUGH ACCESS CHANNEL
SCISCO ISLAND
PLATE 9
PLATE 12
PLATE 13
PLATE 14
A-87-5
A-87-6
A-87-7
A-88-1
A-88-2
A-88-3
A-88-6
A-88-7
A-88-8
A-88-10
A-88-11
A-88-12
A-88-13
SCALE
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ANDALUSIA SLOUGH
ALTERNATIVE PLANS
Scale
As shown
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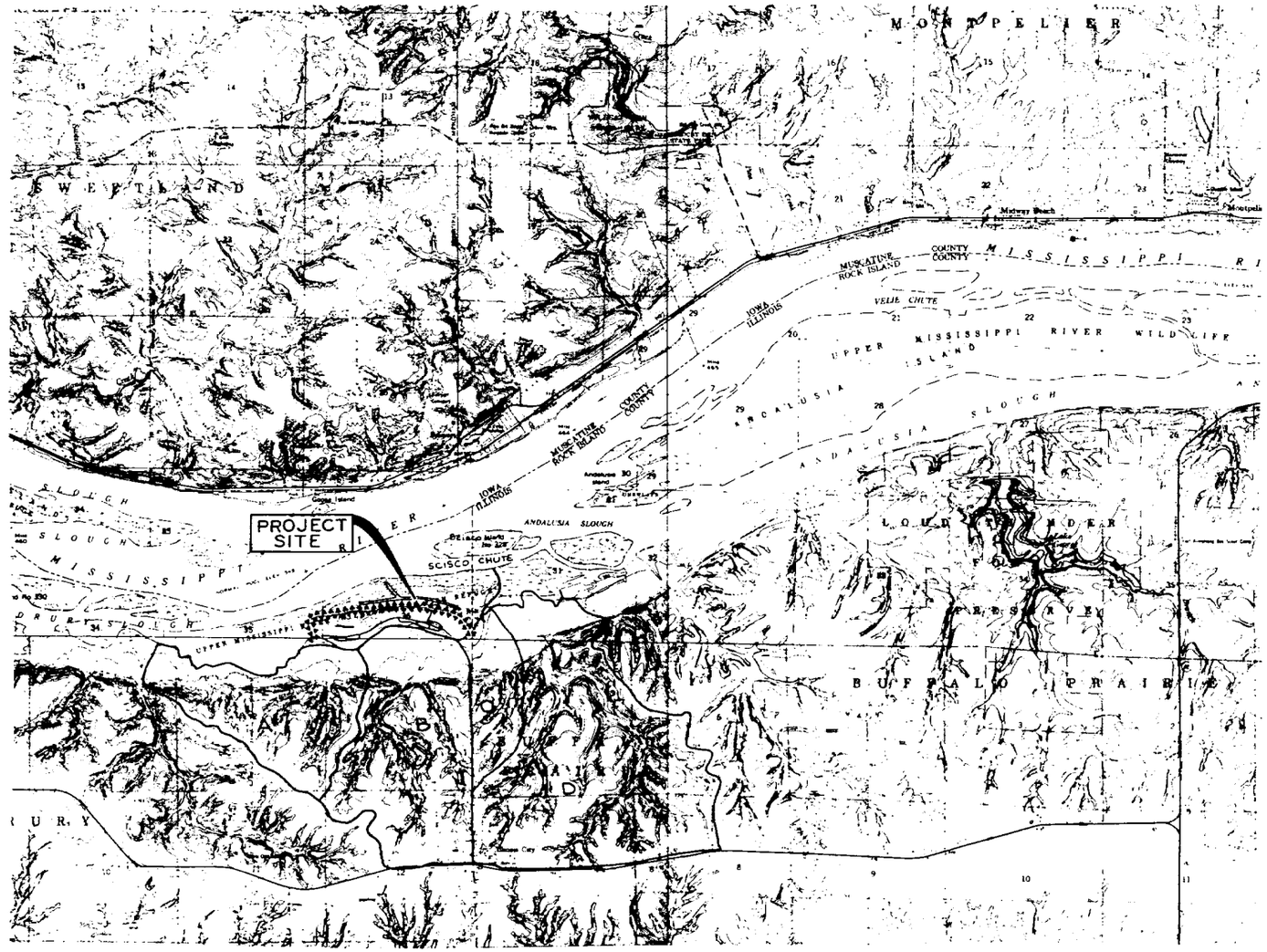
Sheet
of

PLATE 3



ADJACENT WATERSHEDS

ADJACENT WATERSHED CHARACTERISTICS

Watershed	Area, acres	Sediment Yield. AC-FT/Year
A	519	2.2
B	774	3.8
C	208	0.8
D	1152	4.2

SCALE 1:24000

CONTOUR INTERVAL 10 FEET

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POOL 16, RIVER MILE 462.7
ANDALUSIA SLOUGH

ADJACENT WATERSHEDS

Scale: As shown
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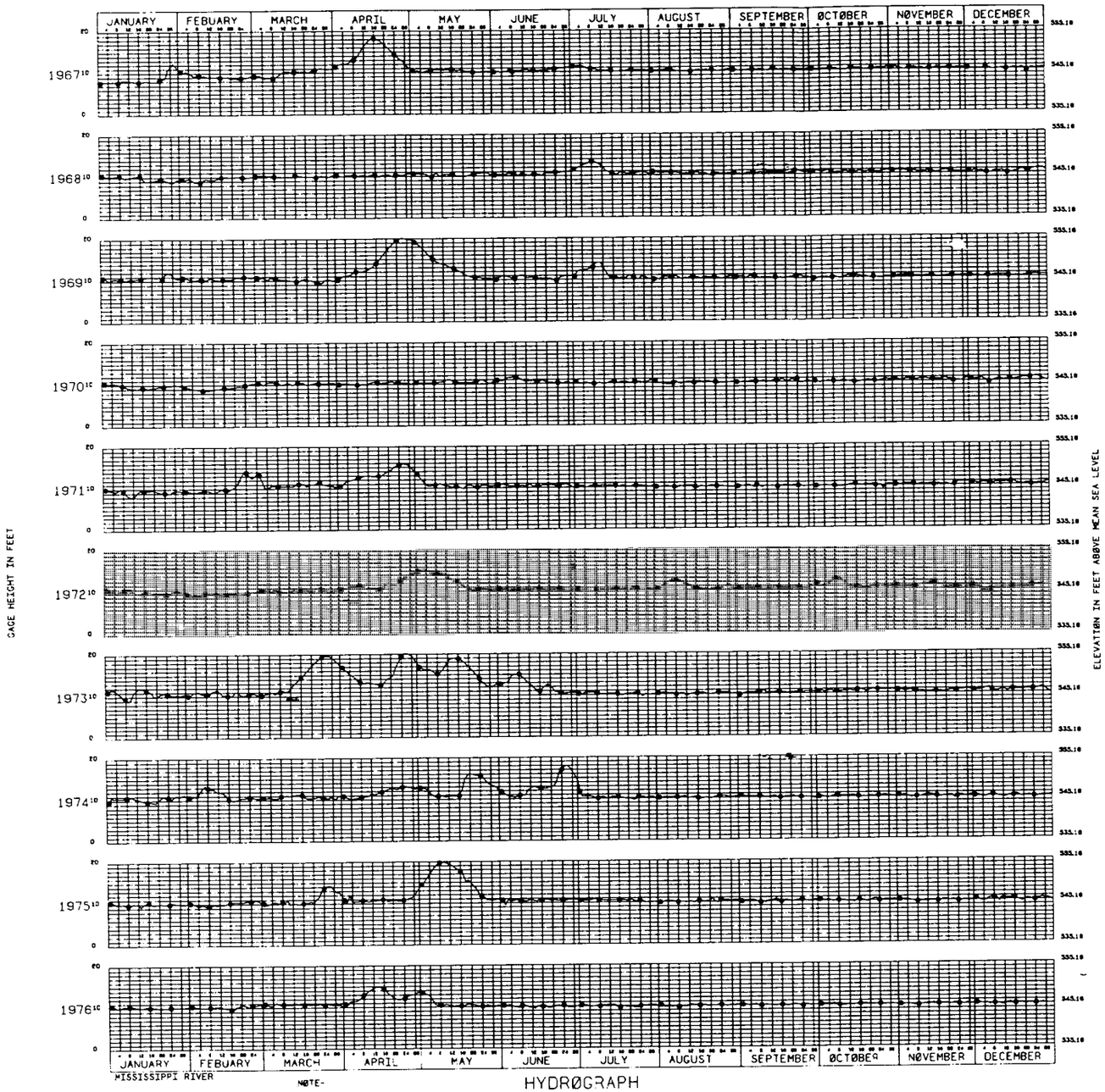
Sheet reference number:
Sheet __ of __

PLATE 4



HYDRØGRAPH
- FAIRPØRT, IØWA

FLOOD PROFILES AT FAIRPORT, IOWA
River Mile 463.5

Event	Elevation
1.5	549.0
2	550.8
5	553.0
10	554.8
50	558.7
100	559.8

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POOL 16, RIVER MILE 462.7
ANDALUSIA SLOUGH

HYDRAULIC DATA I

Scale: As shown
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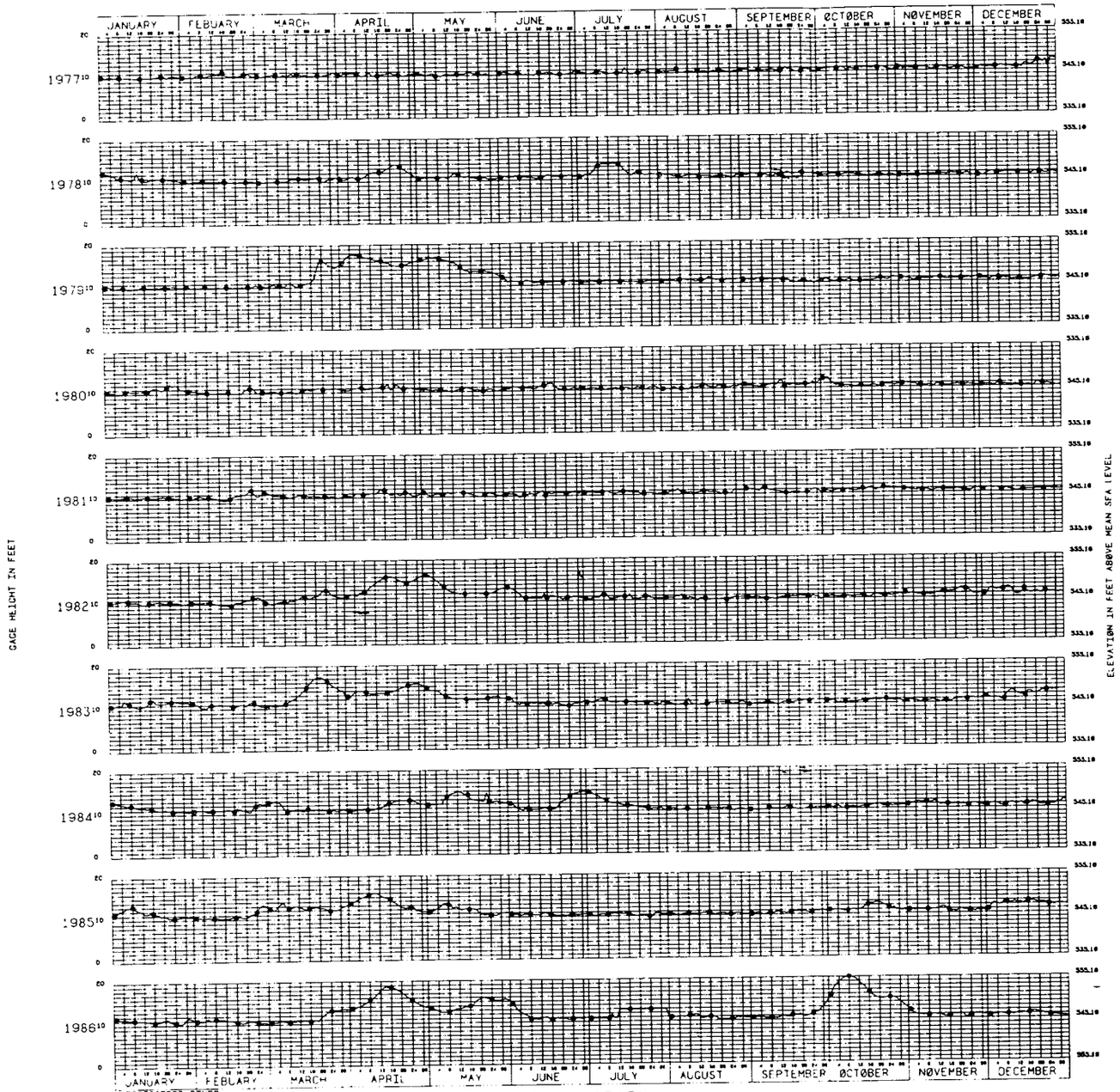
Sheet _ of _

PLATE 5



HYDRØGRAPH
- FAIRPØRT, IØWA

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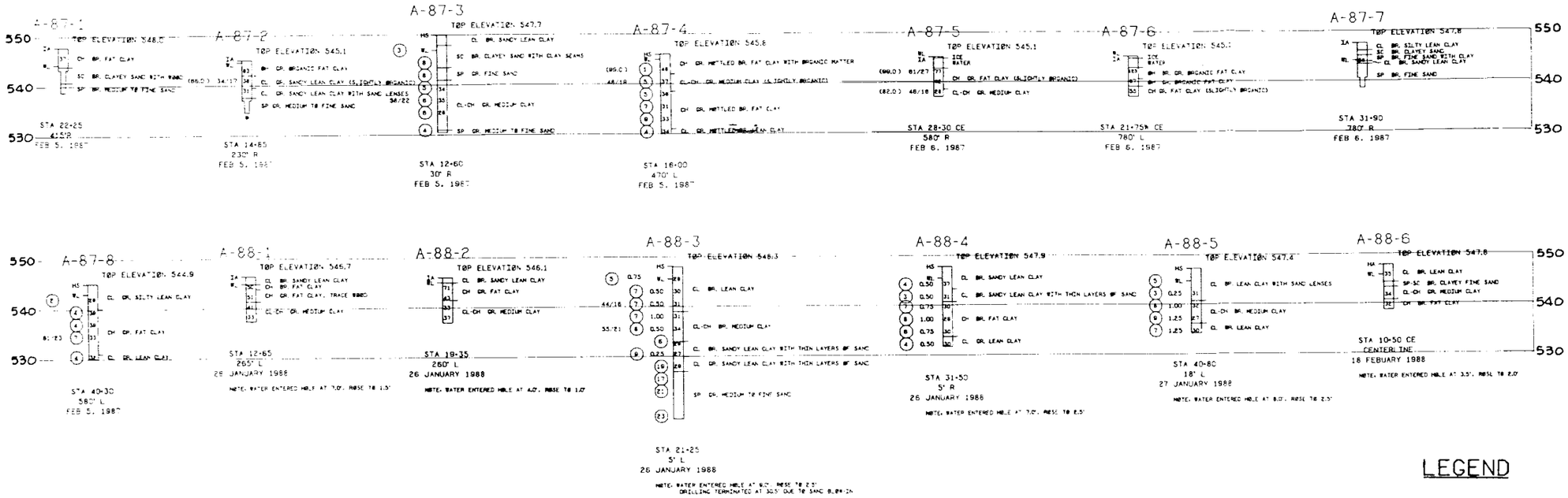
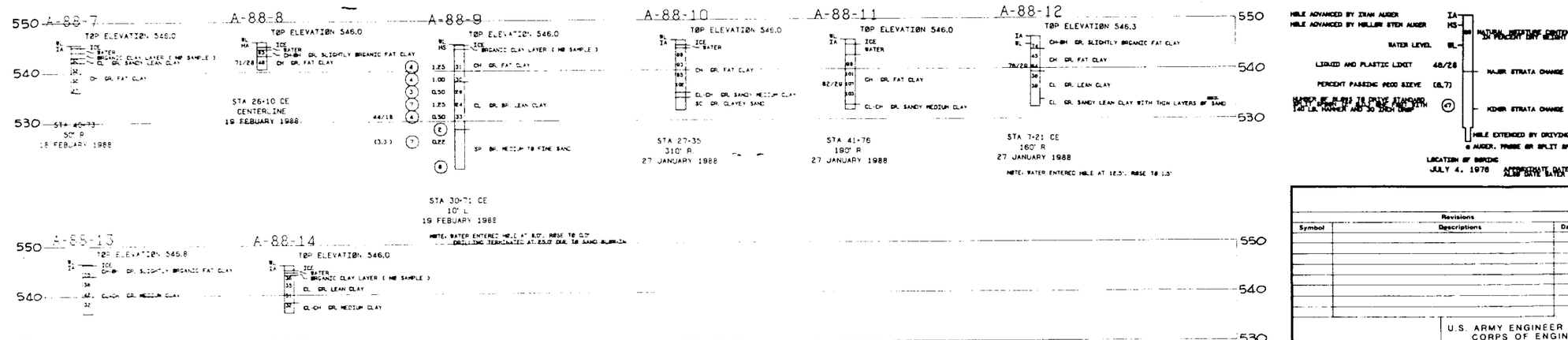
POOL 16, RIVER MILE 482.7
ANDALUSIA SLOUGH

HYDRAULIC DATA II

Scale: As shown
Date:
Drawing Code:
Sheet reference number:
Sheet _ of _

PLATE 6





LEGEND

BORING NUMBER

- HOLE ADVANCED BY 2¼in AUGER — IA
- HOLE ADVANCED BY HOLLOW STEM AUGER — HS
- NATURAL MOISTURE CONTENT 20 PERCENT DRY WEIGHT
- WATER LEVEL — WL
- LIQUID AND PLASTIC LIMIT 48/28
- PERCENT PASSING #200 SIEVE (8.7)
- MAJOR STRATA CHANGE
- NUMBER OF BLOWS TO DRIVE STANDARD SPLIT SPOON 12" A DISTANCE OF 6" WITH 140 LB. HAMMER AND 30 INCH DROP — (17)
- MINOR STRATA CHANGE
- HOLE EXTENDED BY DRIVING 2 INCH PIPE & AUGER, PROBE OR SPLIT SPOON REFUSAL

LOCATION OF BORING — JULY 4, 1978 — APPROXIMATE DATE OF DRILLING AND DATE WATER LEVEL NOTED

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POOL 16, RIVER MILE 462.7
ANDALUSIA SLOUGH
BORING LOGS

Scale: As shown
Date:
Drawing Code:
Sheet reference number:
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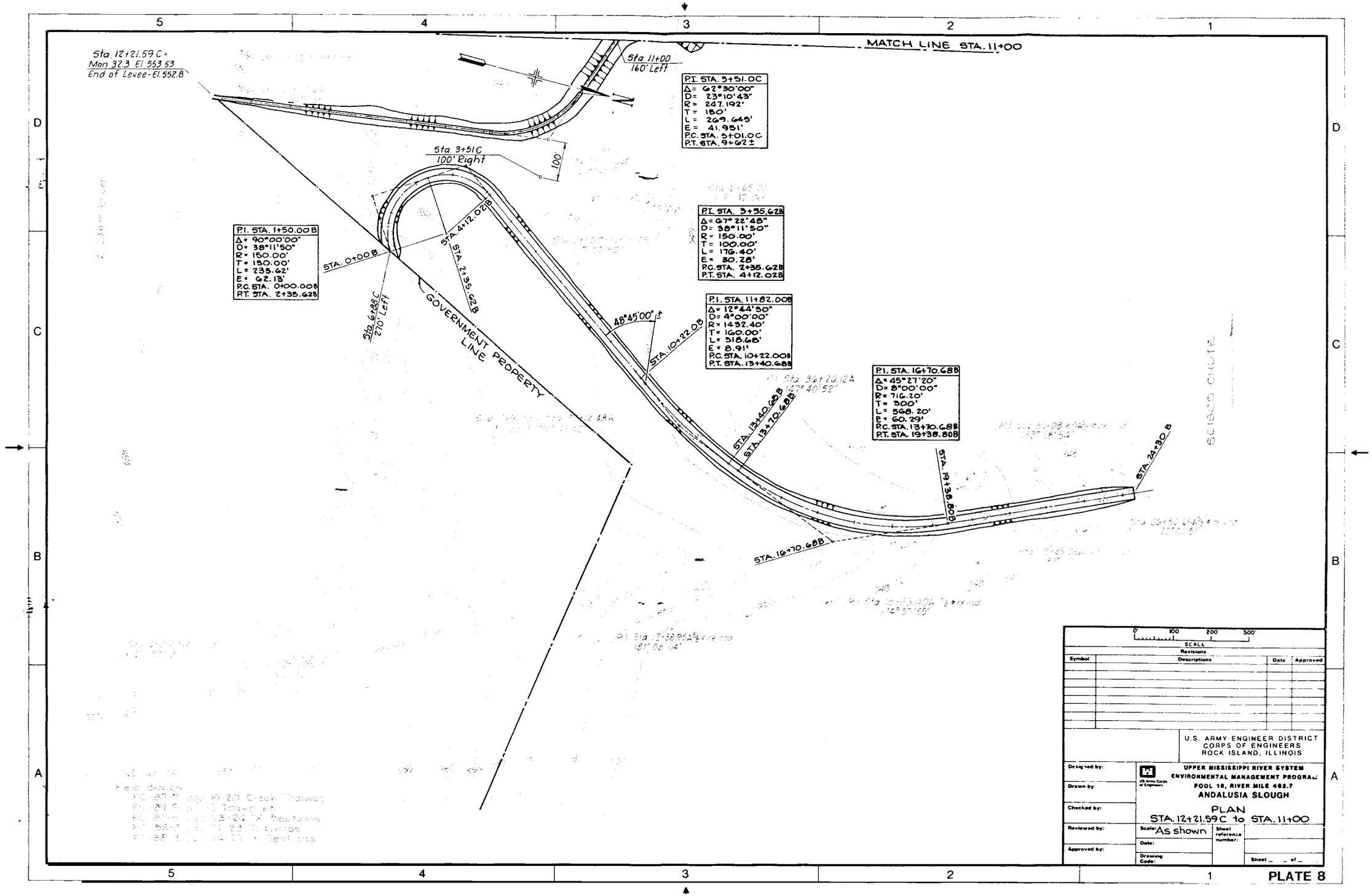
PLATE 7


MATCH LINE STA. 11+00
Sta. 12+21.59 C = Mon 32.3 El 553.53 End of Levee - El. 552.8
Sta 11+00 160' Left
P.I. STA. 5+51.0C
Δ = 62°30'00"
D = 23°10'43"
R = 247.192'
T = 160'
L = 269.645'
E = 41.951'
P.C. STA. 5+01.0C
P.T. STA. 9+62 ±
Sta 3+51C 100' Right
100'
P.I. STA. 3+35.62B
Δ = 67°22'48"
D = 38°11'50"
R = 150.00'
T = 100.00'
L = 176.40'
E = 30.28'
P.C. STA. 2+35.62B
P.T. STA. 4+12.02B
P.I. STA. 1+50.00B
Δ = 90°00'00"
D = 38°11'50"
R = 150.00'
T = 150.00'
L = 235.62'
E = 62.13'
P.C. STA. 0+00.00B
P.T. STA. 2+35.62B
STA. 0+00B
STA. 4+12.02B
STA. 2+35.62B
Sta 6+88C 270' Left
GOVERNMENT LINE PROPERTY
46°45'00" ±
STA. 10+22.0B
P.I. STA. 11+82.00B
Δ = 12°44'50"
D = 4°00'00"
R = 1432.40'
T = 160.00'
L = 318.68'
E = 8.91'
P.C. STA. 10+22.00B
P.T. STA. 13+40.68B
P.I. STA. 16+70.68B
Δ = 45°27'20"
D = 8°00'00"
R = 716.20'
T = 300'
L = 568.20'
E = 60.29'
P.C. STA. 13+70.68B
P.T. STA. 19+38.80B
STA. 13+40.68B
STA. 13+70.68B
STA. 19+38.80B
STA. 24+30.8
STA. 16+70.68B
SCISCO CHUTE
0' 100' 200' 300'
SCALE
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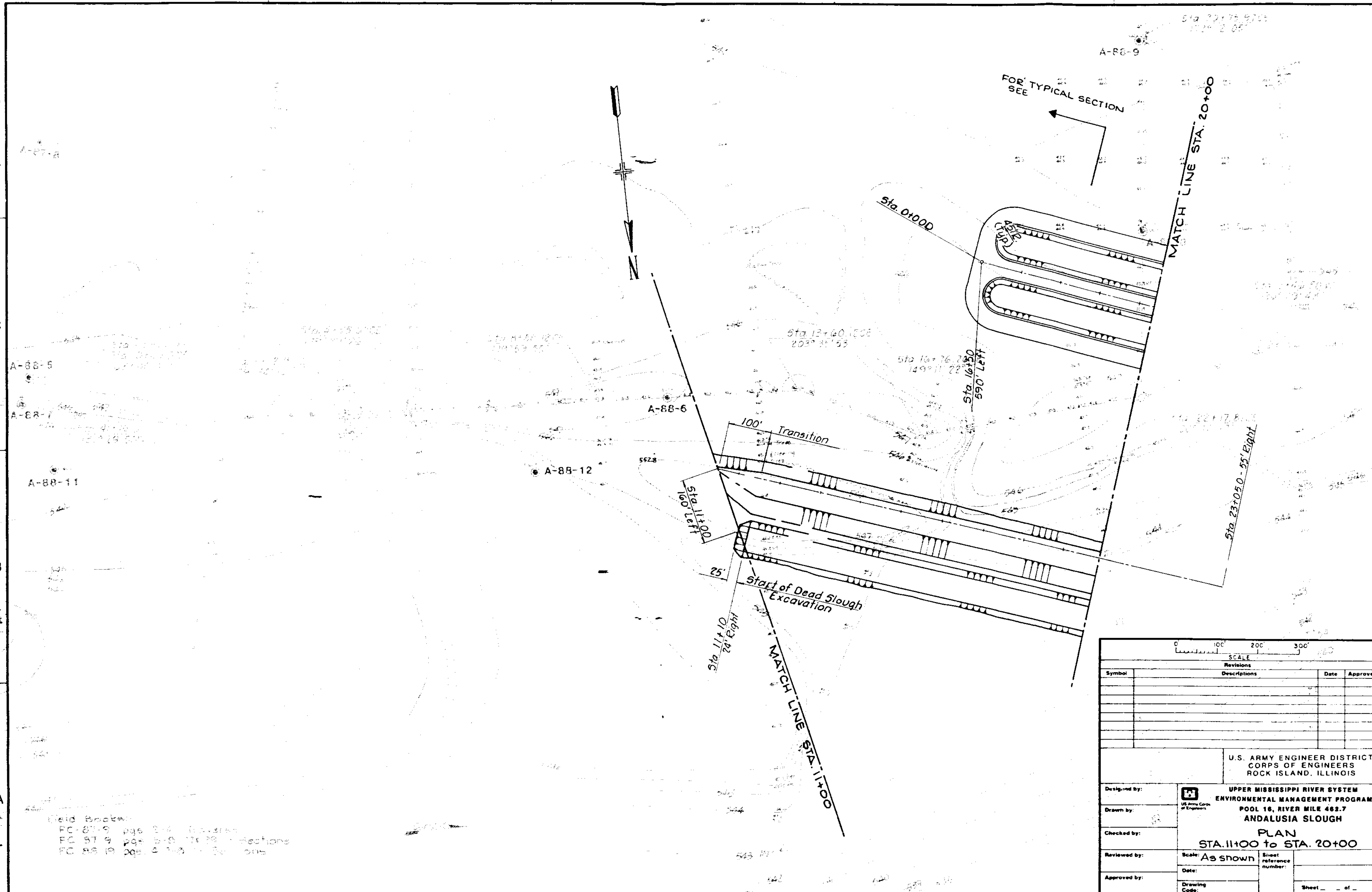
ANDALUSIA SLOUGH
PLAN
STA. 12+21.59C to STA. 11+00
Scale: As shown
Date:
Drawing Code:
Sheet reference number:
Sheet _ _ of _
PLATE 8



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UPPER MISSISSIPPI RIVER SYSTEM
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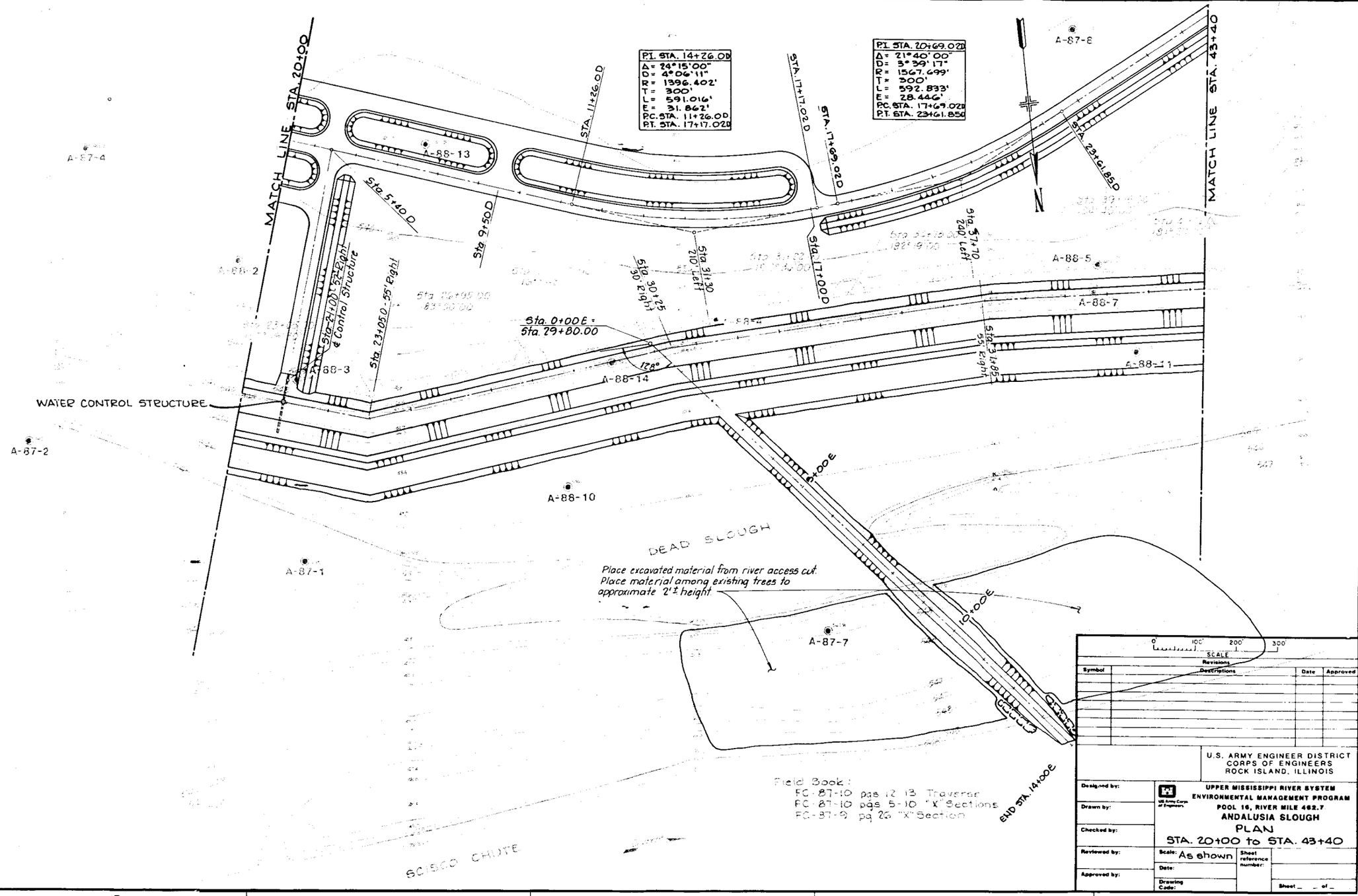
POOL 16, RIVER MILE 462.7
ANDALUSIA SLOUGH

PLAN
STA. 11+00 to STA. 20+00

Scale: As shown
Date:
Drawing Code:
Sheet reference number:
Sheet _ _ of _

PLATE 9


MATCH LINE STA. 20+00
MATCH LINE STA. 43+40
P.I. STA. 14+26.00
Δ = 24°15'00"
D = 4°06'11"
R = 1396.402'
T = 300'
L = 591.016'
E = 31.862'
PC STA. 11+26.00
PT. STA. 17+17.02
P.I. STA. 20+69.02
Δ = 21°40'00"
D = 3°39'17"
R = 1567.699'
T = 300'
L = 592.833'
E = 28.446'
PC STA. 17+69.02
PT. STA. 23+61.85
STA. 11+26.00
STA. 17+17.02
STA. 17+69.02
STA. 23+61.85
Sta 5+40.00
Sta 9+50.00
Sta 17+00.00
Sta 31+30 210' Left
Sta 30+25 30' Right
Sta 37+70 240' Left
Sta 23+85 55' Eight
Sta 23+05.0 - 55' Eight
Sta 21+00 55' Right
& Control Structure
Sta. 0+00E = Sta. 29+80.00
0+00E
12+00E
WATER CONTROL STRUCTURE
A-87-8
A-87-4
A-87-2
A-87-1
A-87-7
A-88-13
A-88-2
A-88-3
A-88-14
A-88-10
A-88-5
A-88-7
A-88-11
DEAD SLOUGH
SCISCO CHUTE
Place excavated material from river access cut. Place material among existing trees to approximate 2'± height.
END STA. 14+00E
N
Field Book:
FC-87-10 pgs 12 13 Traverse
FC-87-10 pgs 5-10 "X" Sections
FC-87-9 pg 26 "X" Section
0' 100' 200' 300'
SCALE
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Date
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UPPER MISSISSIPPI RIVER SYSTEM
ENVIRONMENTAL MANAGEMENT PROGRAM
POOL 16, RIVER MILE 462.7
ANDALUSIA SLOUGH
PLAN
STA. 20+00 to STA. 43+40
Scale: As shown
Date:
Drawing Code:
Sheet reference number:
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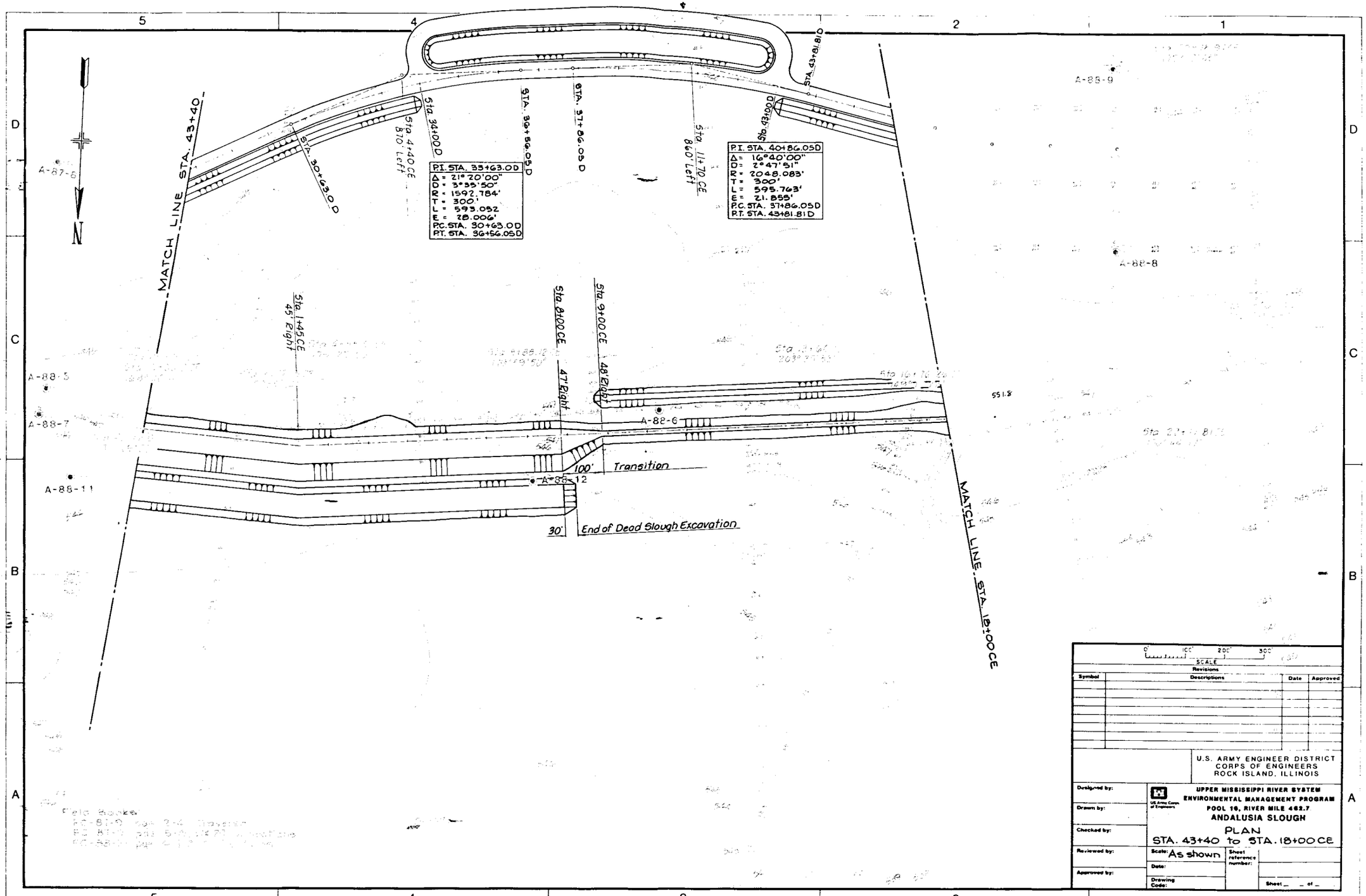
PLATE 10


MATCH LINE STA. 43+40
Sta 34+00 D
STA. 30+63.0 D
Sta 4+40 CE 810' Left
STA. 30+56.05 D
STA. 37+86.05 D
Sta 11+70 CE 860' Left
Sta 43+00 D
STA. 43+81.81 D
P.I. STA. 33+63.0D
Δ = 21° 20' 00"
D = 3° 35' 50"
R = 1592.784'
T = 300'
L = 593.052
E = 28.006'
P.C. STA. 30+63.0D
P.T. STA. 36+56.05D
P.I. STA. 40+86.05D
Δ = 16° 40' 00"
D = 2° 47' 51"
R = 2048.083'
T = 300'
L = 595.763'
E = 21.855'
P.C. STA. 37+86.05D
P.T. STA. 43+81.81D
Sta 1+45 CE 45' Right
Sta 8+00 CE 47' Right
Sta 9+00 CE 48' Right
A-88-5
A-88-7
A-88-11
A-88-6
A-88-12
A-88-9
A-88-8
100' Transition
30' End of Dead Slough Excavation
MATCH LINE STA. 18+00 CE
N
SCALE
0 100 200 300
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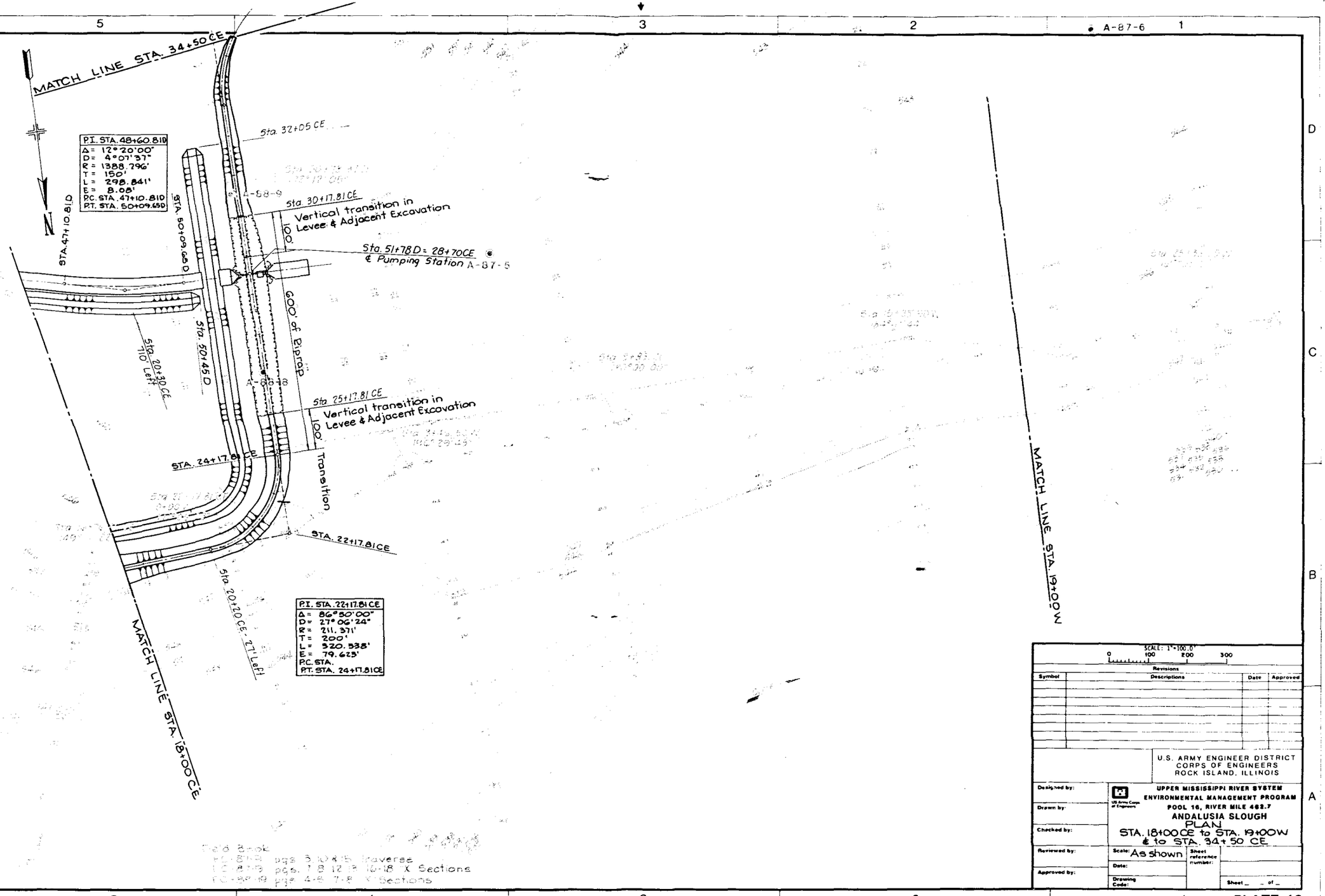
POOL 16, RIVER MILE 462.7
ANDALUSIA SLOUGH
PLAN
STA. 43+40 to STA. 18+00 CE
Scale: As shown
Date:
Drawing Code:
Sheet reference number:
Sheet _ of _

PLATE 11



SCALE: 1"=100.0'
0 100 200 300

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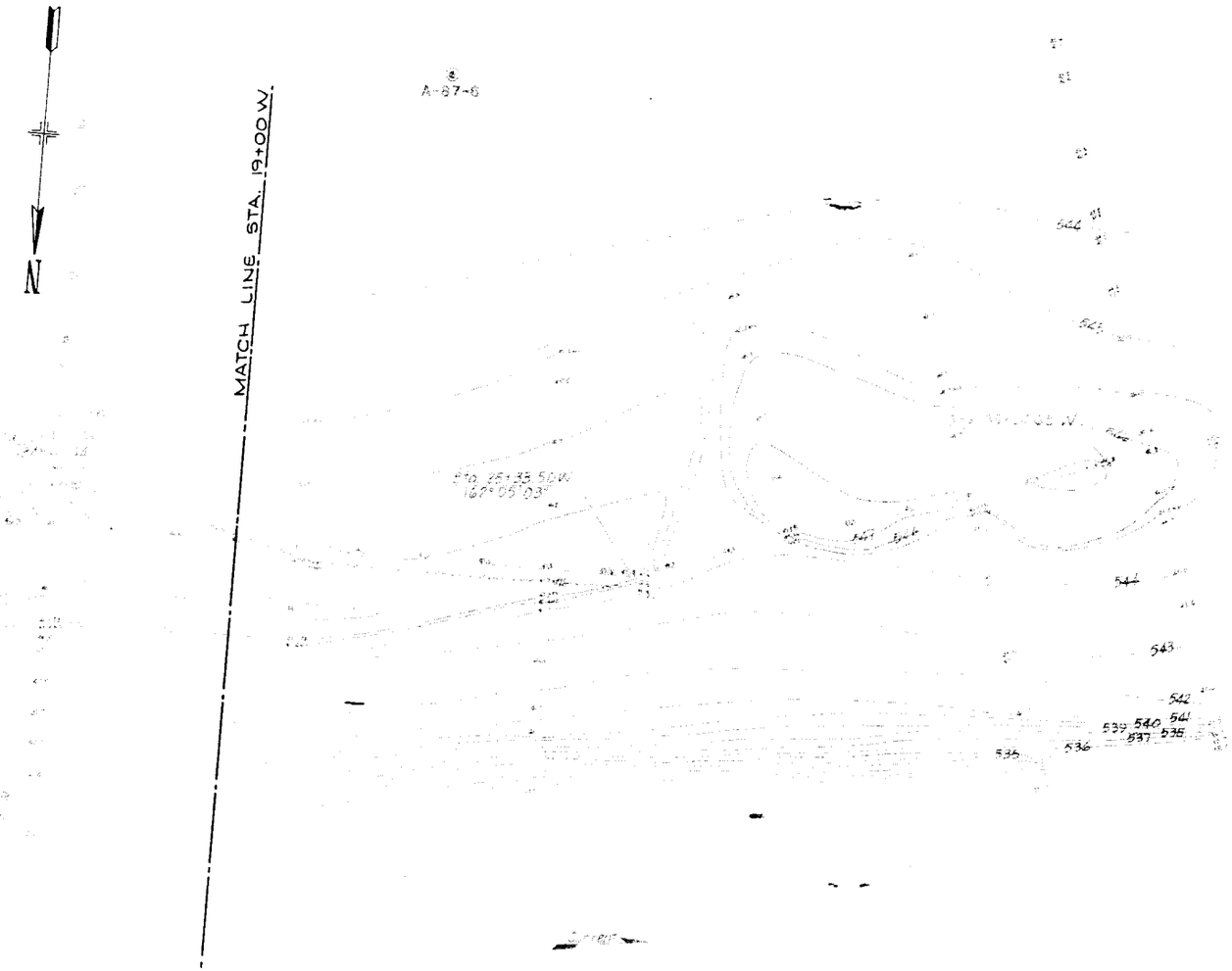
UPPER MISSISSIPPI RIVER SYSTEM
ENVIRONMENTAL MANAGEMENT PROGRAM
POOL 16, RIVER MILE 462.7

ANDALUSIA SLOUGH
PLAN
STA. 18+00 CE to STA. 19+00 W & to STA. 34+50 CE

Scale: As shown
Date:
Drawing Code:
Sheet reference number:
Sheet _ of _

PLATE 12



This Plate was provided to show area of not recommended bank protection (Alternative F). Monitoring ranges have been established in this area as shown on Plate 23.

0 100' 200' 300'
SCALE

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U.S. ARMY ENGINEER DISTRICT
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Approved by:
NEIL A. SMART
COL., CORPS OF ENGINEERS

US Army Corps of Engineers

UPPER MISSISSIPPI RIVER SYSTEM
ENVIRONMENTAL MANAGEMENT PROGRAM
POOL 16, RIVER MILE 462.7
ANDALUSIA SLOUGH
PLAN
STA. 19+00W to STA. 33+24.65W

Scale: As shown
Date:
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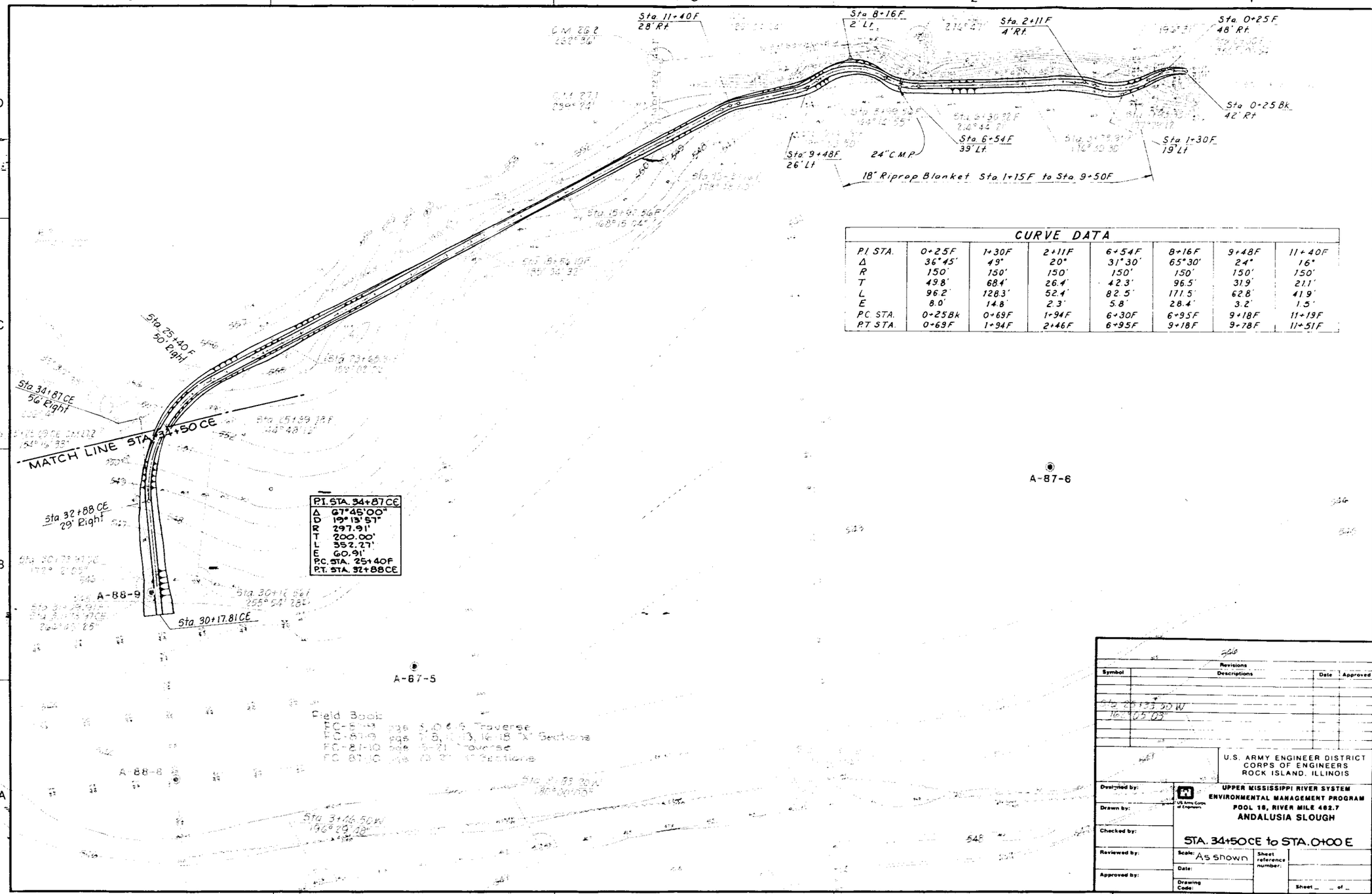
Sheet reference number:
Sheet _ _ of _

PLATE 13



CURVE DATA

P.I. STA.	0+25F	1+30F	2+11F	6+54F	8+16F	9+48F	11+40F
Δ	36°45'	49°	20°	31°30'	65°30'	24°	16°
R	150'	150'	150'	150'	150'	150'	150'
T	49.8'	68.4'	26.4'	42.3'	96.5'	31.9'	21.1'
L	96.2'	128.3'	52.4'	82.5'	171.5'	62.8'	41.9'
E	8.0'	14.8'	2.3'	5.8'	28.4'	3.2'	1.5'
P.C. STA.	0+25Bk	0+69F	1+94F	6+30F	6+95F	9+18F	11+19F
P.T. STA.	0+69F	1+94F	2+46F	6+95F	9+18F	9+78F	11+51F

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ENVIRONMENTAL MANAGEMENT PROGRAM
POOL 18, RIVER MILE 482.7
ANDALUSIA SLOUGH

STA. 34+50CE to STA. 0+00 E

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Scale: As shown
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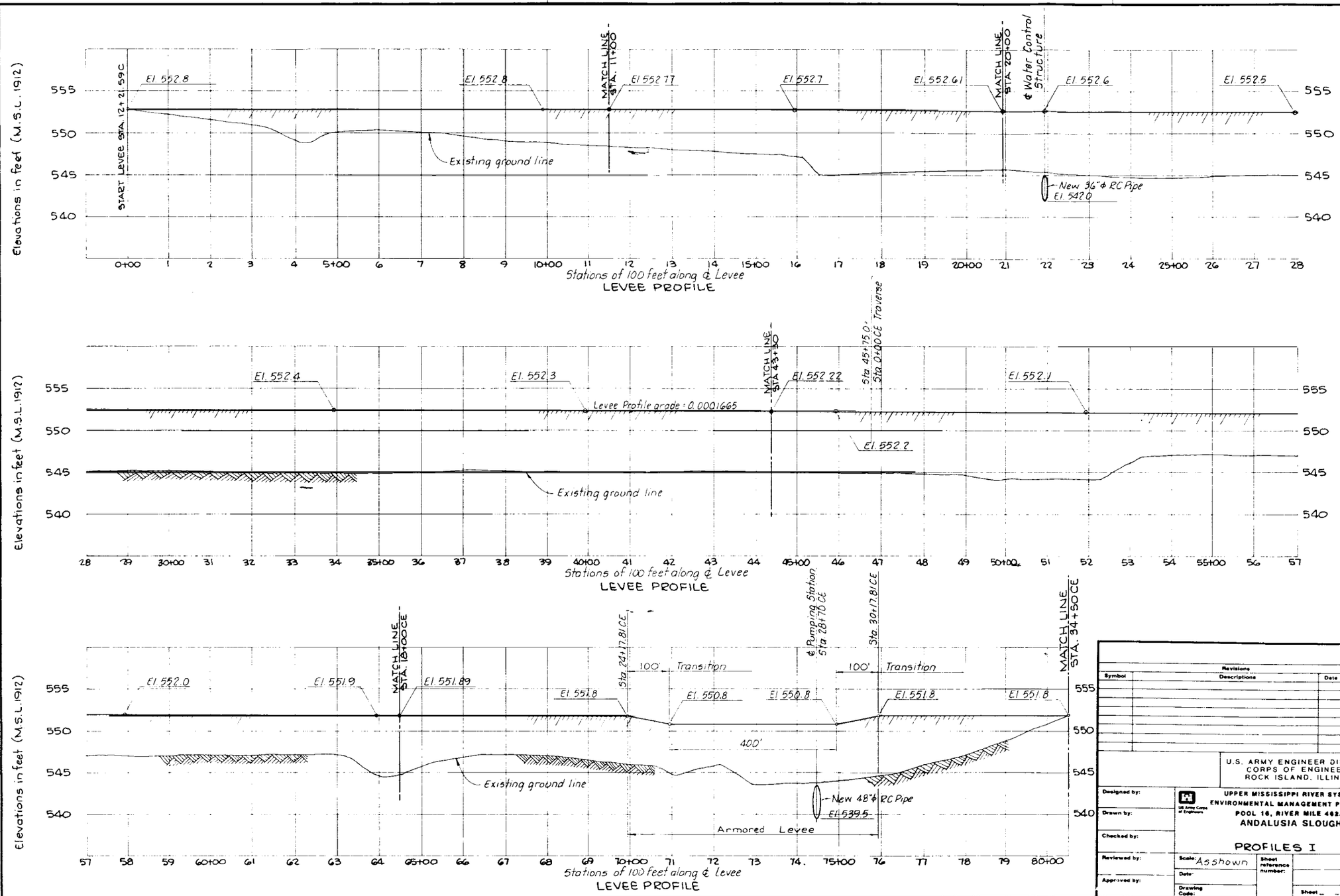
Sheet _ of _

PLATE 14


Elevations in feet (M.S.L. 1912)
START LEVEE STA. 12+21.59C
El. 552.8
El. 552.8
MATCH LINE STA. 11+00
El. 552.77
El. 552.7
El. 552.61
MATCH LINE STA. 20+00
℄ Water Control Structure
El. 552.6
El. 552.5
Existing ground line
New 36"ϕ RC Pipe El. 542.0
555
550
545
540
0+00 1 2 3 4 5+00 6 7 8 9 10+00 11 12 13 14 15+00 16 17 18 19 20+00 21 22 23 24 25+00 26 27 28
Stations of 100 feet along ℄ Levee
LEVEE PROFILE
Elevations in feet (M.S.L. 1912)
El. 552.4
El. 552.3
MATCH LINE STA 43+50
Sta 45+75.0 Sta 01+00CE Traverse
El. 552.22
El. 552.1
Levee Profile grade - 0.0001665
El. 552.2
Existing ground line
555
550
545
540
28 29 30+00 31 32 33 34 35+00 36 37 38 39 40+00 41 42 43 44 45+00 46 47 48 49 50+00 51 52 53 54 55+00 56 57
Stations of 100 feet along ℄ Levee
LEVEE PROFILE
Elevations in feet (M.S.L. 1912)
MATCH LINE STA. 18+00CE
Sta 24+17.81CE
℄ Pumping Station Sta 28+10 CE
Sta. 30+17.81CE
MATCH LINE STA. 34+50CE
El. 552.0
El. 551.9
El. 551.89
El. 551.8
100' Transition
El. 550.8
El. 550.8
100' Transition
El. 551.8
El. 551.8
400'
Existing ground line
New 48"ϕ RC Pipe El. 539.5
Armored Levee
555
550
545
540
57 58 59 60+00 61 62 63 64 65+00 66 67 68 69 70+00 71 72 73 74 75+00 76 77 78 79 80+00
Stations of 100 feet along ℄ Levee
LEVEE PROFILE
Revisions
Symbol | Descriptions | Date | Approved
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS
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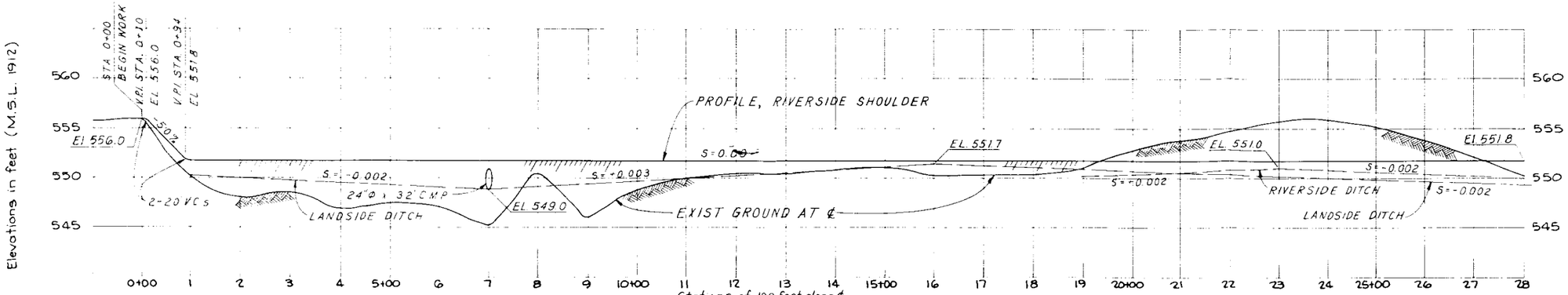
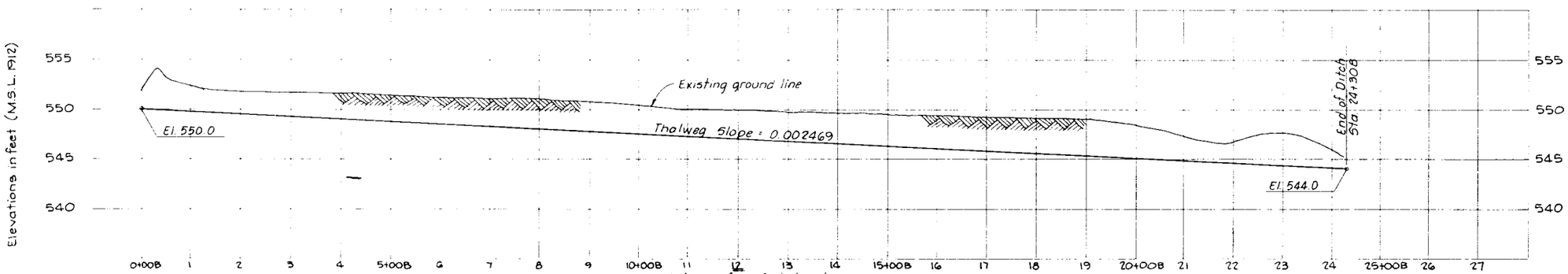
Approved by:
UPPER MISSISSIPPI RIVER SYSTEM
ENVIRONMENTAL MANAGEMENT PROGRAM
POOL 16, RIVER MILE 462.7.
ANDALUSIA SLOUGH
PROFILES I
Scale: As shown
Date:
Drawing Code:
Sheet reference number:
Sheet _ _ of _

PLATE 15



ACCESS ROAD PROFILE



DIVERSION DRAINAGE DITCH PROFILE

Revisions			
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U.S. ARMY ENGINEER DISTRICT
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UPPER MISSISSIPPI RIVER SYSTEM
ENVIRONMENTAL MANAGEMENT PROGRAM
POOL 16, RIVER MILE 462.7
ANDALUSIA SLOUGH

PROFILES II

Scale: As shown
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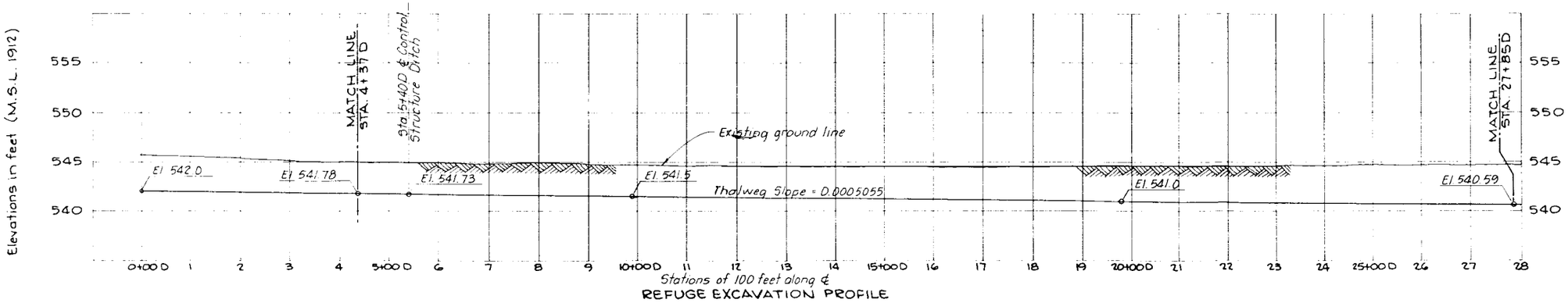
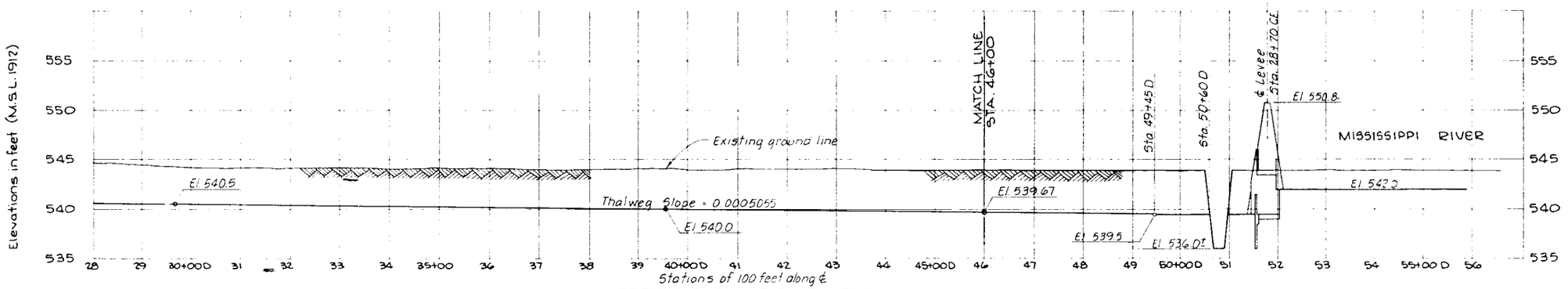
Sheet reference number:
Sheet __ of __

PLATE 16



REFUGE EXCAVATION PROFILE



REFUGE EXCAVATION PROFILE

Revisions			
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U.S. ARMY ENGINEER DISTRICT
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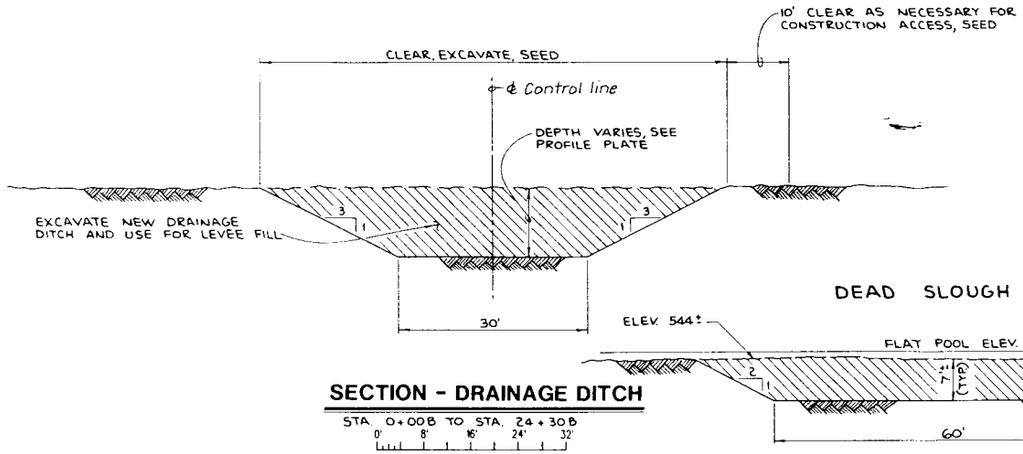
UPPER MISSISSIPPI RIVER SYSTEM
ENVIRONMENTAL MANAGEMENT PROGRAM
POOL 16, RIVER MILE 462.7
ANDALUSIA SLOUGH

PROFILES III

Scale: As shown
Date:
Drawing Code:
Sheet reference number:
Sheet _ _ of _

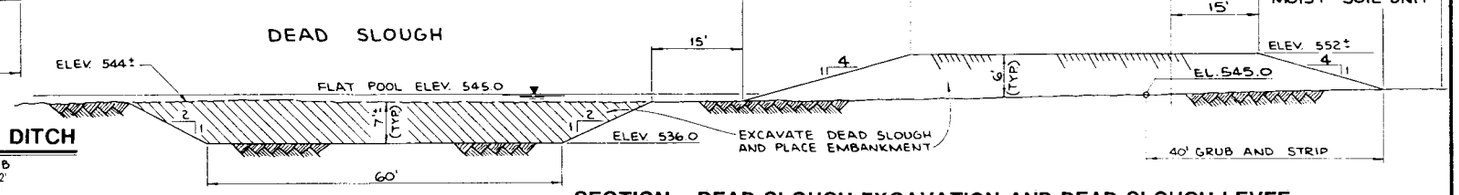
PLATE 17

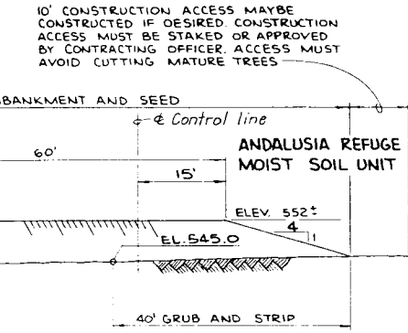


SECTION - DRAINAGE DITCH

STA. 0+00B TO STA. 24+30B

0' 8' 16' 24' 32'



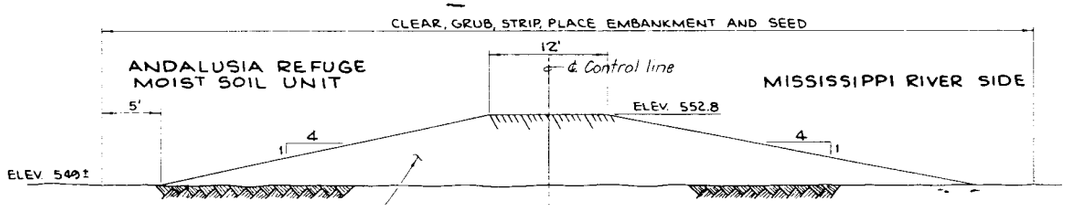


SECTION - DEAD SLOUGH EXCAVATION AND DEAD SLOUGH LEVEE

STA. 12+00 TO STA. 8+00 CE

NO SCALE

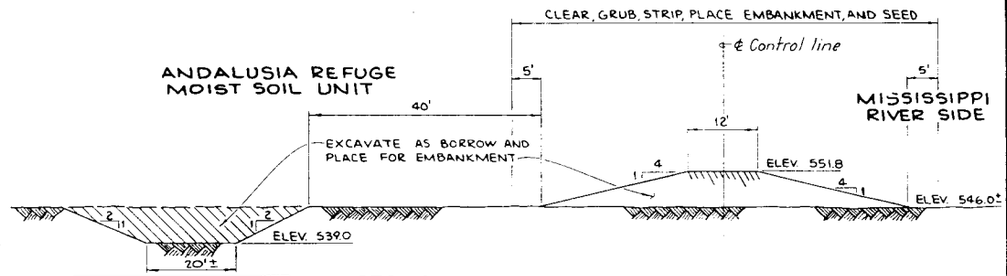
100' TRANSITION FROM STA. 11+00 TO STA. 12+00



SECTION - LEVEE

STA. 12+21.59C TO STA. 11+00

NO SCALE

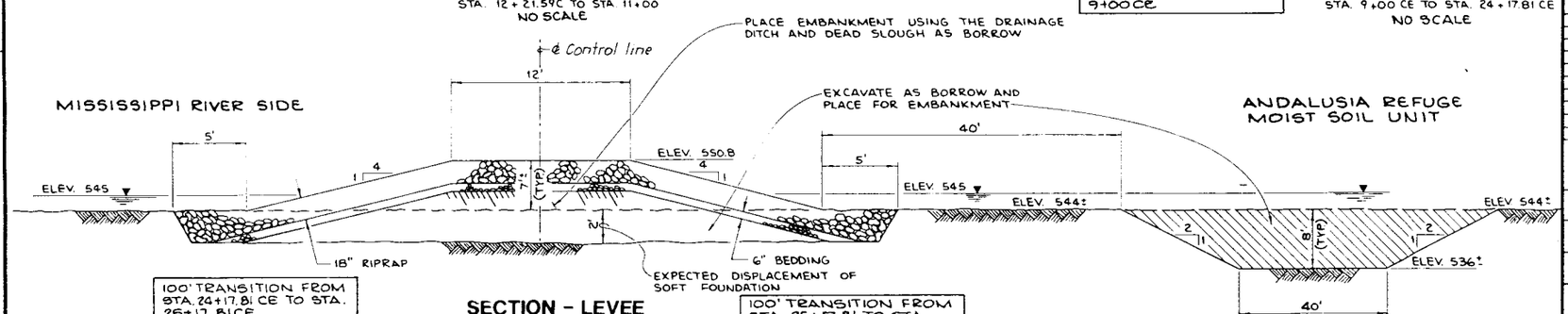


100' TRANSITION FROM STA. 8+00CE TO STA. 9+00CE

SECTION - LEVEE

STA. 9+00 CE TO STA. 24+17.81 CE

NO SCALE



100' TRANSITION FROM STA. 24+17.81 CE TO STA. 25+17.81CE

SECTION - LEVEE

STA. 25+17.81CE TO STA. 29+17.81CE

NO SCALE

100' TRANSITION FROM STA. 25+17.81 TO STA. 30+17.81CE.

Revisions			
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U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

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UPPER MISSISSIPPI RIVER SYSTEM
ENVIRONMENTAL MANAGEMENT PROGRAM
POOL 16, RIVER MILE 482.7
ANDALUSIA SLOUGH

SECTIONS I

Scale: As shown
Date:
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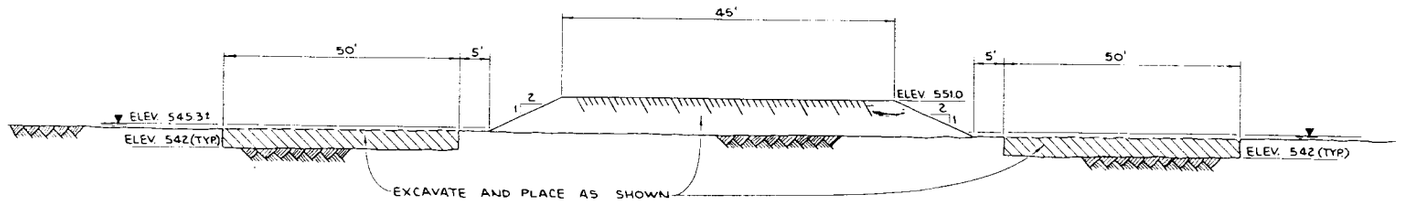
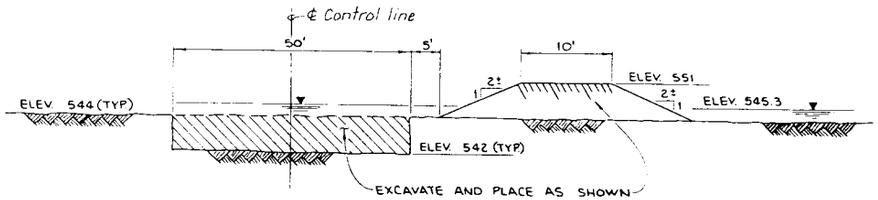
PLATE 18



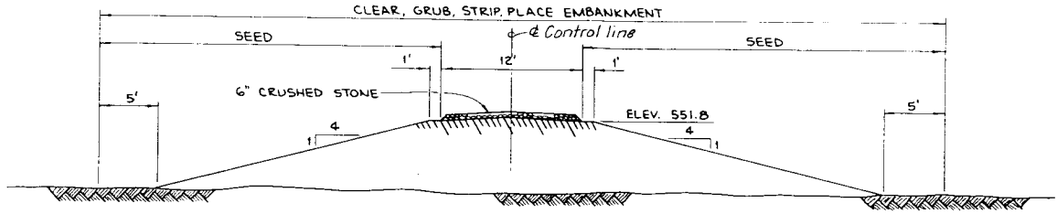
SECTION - REFUGE EXCAVATION TYPE I

STA. 0+00D TO STA. 19+00D
STA. 34+00D TO STA. 43+00D
NO SCALE



SECTION - REFUGE EXCAVATION TYPE II

STA. 19+00D TO STA. 34+00D
STA. 43+00D TO STA. 50+45D
NO SCALE

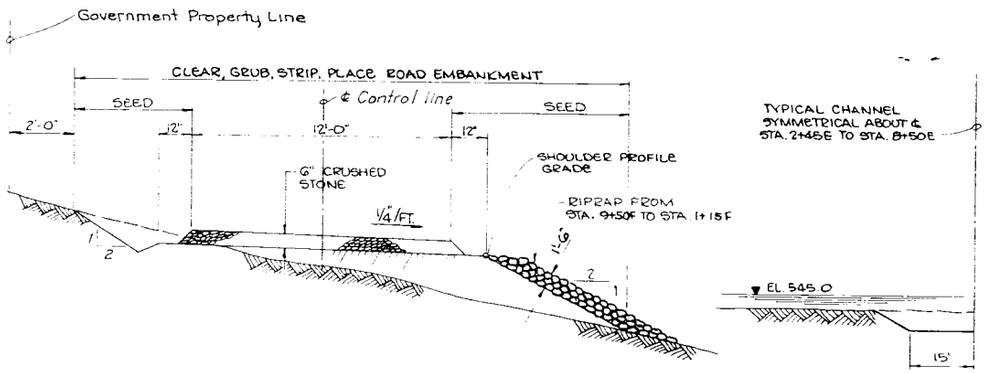


100' TRANSITION FROM STA. 29+17.81CE TO STA. 30+17.81CE

SECTION - LEVEE

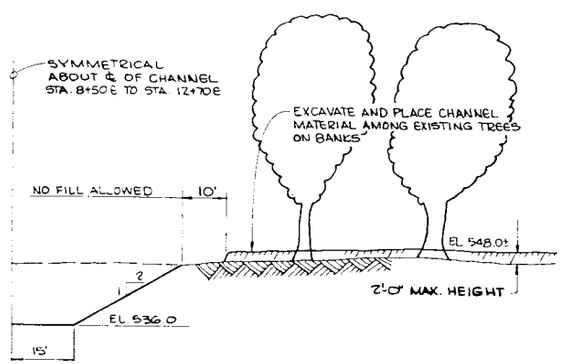
STA. 30+17.81CE TO STA. 34+50 CE

0' 4' 8' 12' 16'



SECTION - ACCESS ROAD (TYP.)

STA. 34+50 CE TO STA. 0+00 F
(NO SCALE)



SECTION - RIVER ACCESS

STA. 2+45E TO STA. 14+00E
(NO SCALE)

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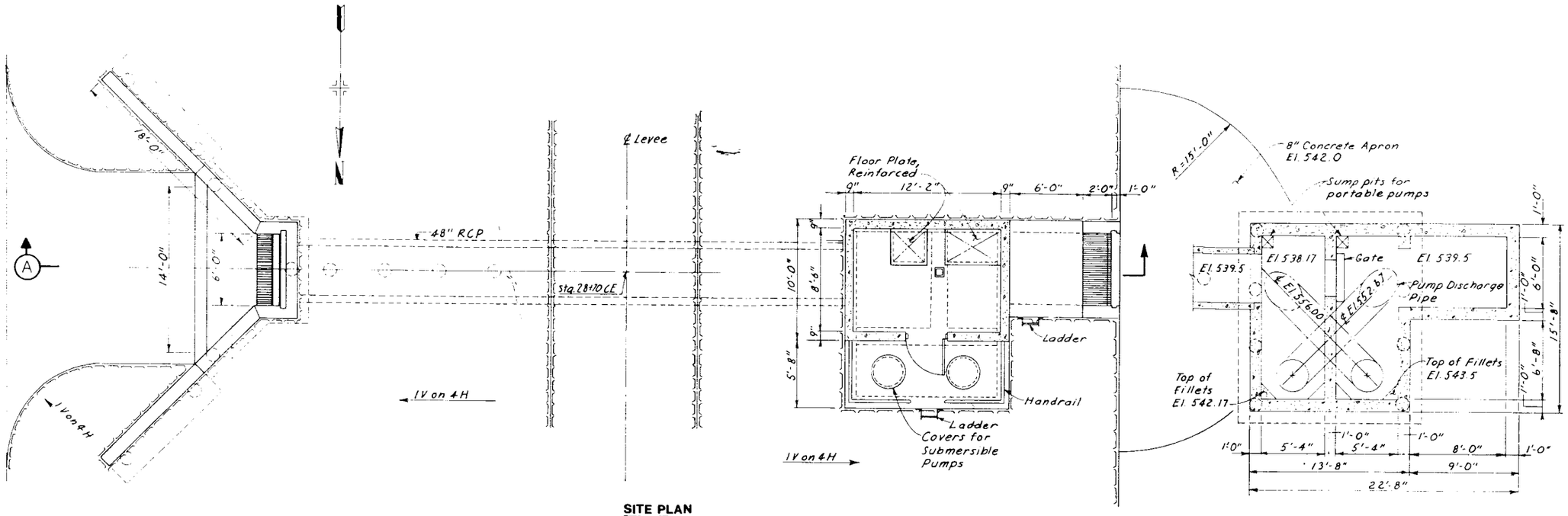
UPPER MISSISSIPPI RIVER SYSTEM
ENVIRONMENTAL MANAGEMENT PROGRAM
POOL 16, RIVER MILE 462.7
ANDALUSIA SLOUGH

SECTIONS II

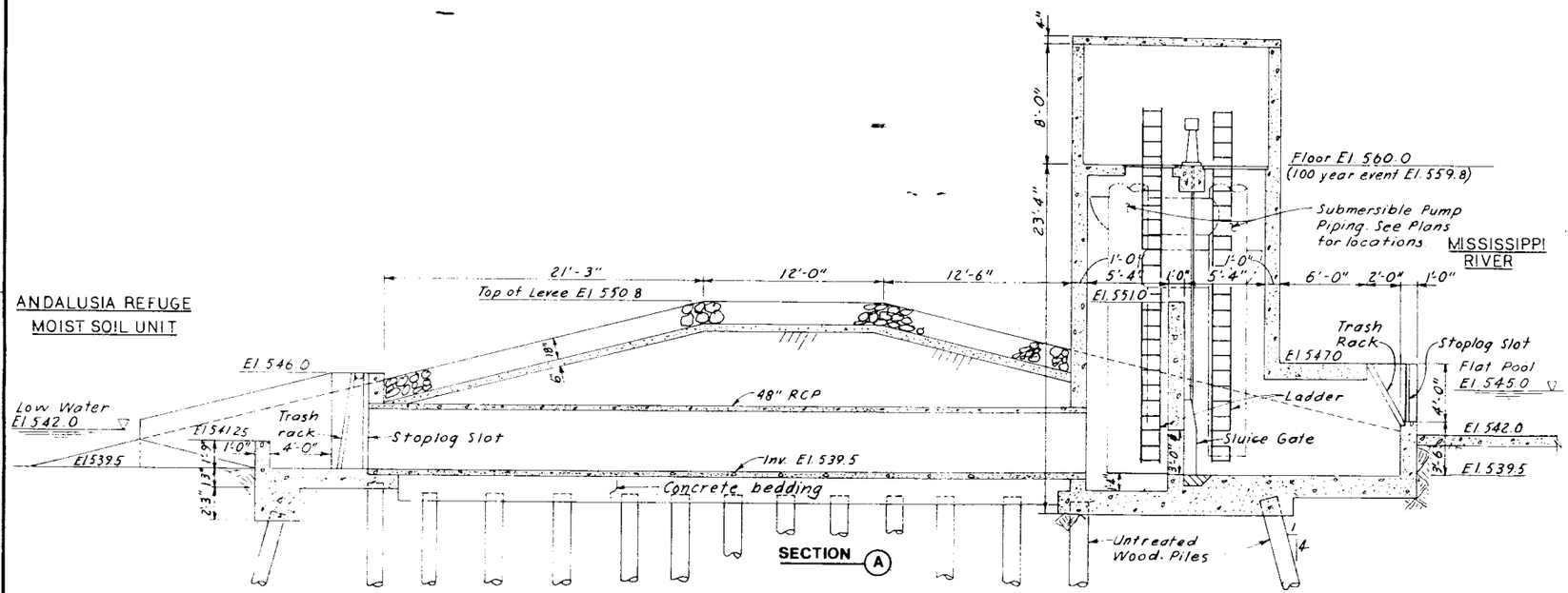
Scale: As shown
Date:
Drawing Code:
Sheet reference number:
Sheet __ of __

PLATE 19



SITE PLAN

SUMP PLAN



SECTION (A)

SCALE 0' 4' 8' 12'

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UPPER MISSISSIPPI RIVER SYSTEM
ENVIRONMENTAL MANAGEMENT PROGRAM
POOL 16, RIVER MILE 482.7
ANDALUSIA SLOUGH

PUMP STATION

Scale: As shown
Date:
Drawing Code:
Sheet reference number:
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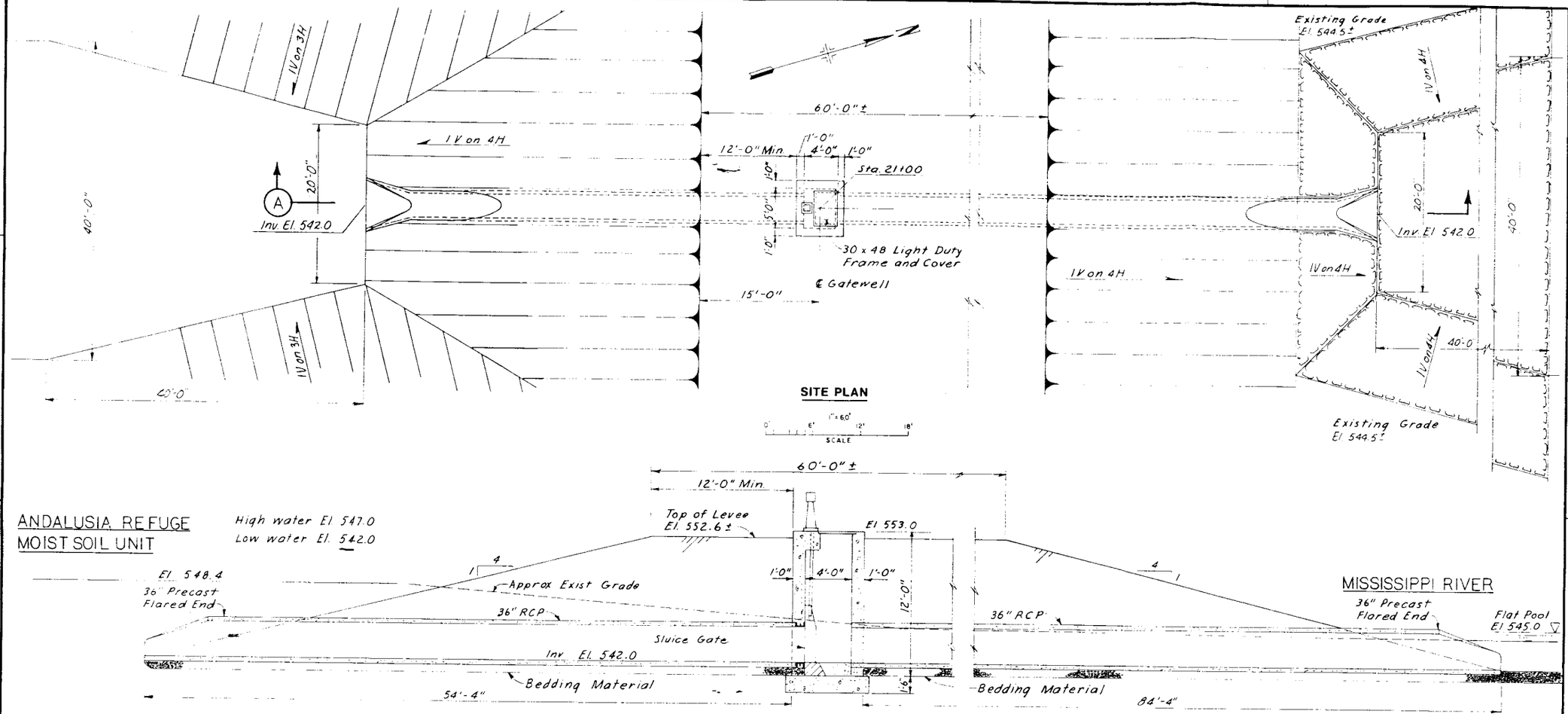
PLATE 20



SITE PLAN

1" = 60'
0' 6' 12' 18'
SCALE

ANDALUSIA REFUGE
MOIST SOIL UNIT

High water El. 547.0
Low water El. 542.0

SECTION (A)

SCALE: 1/4"-1'-0"
0' 4' 8' 12'

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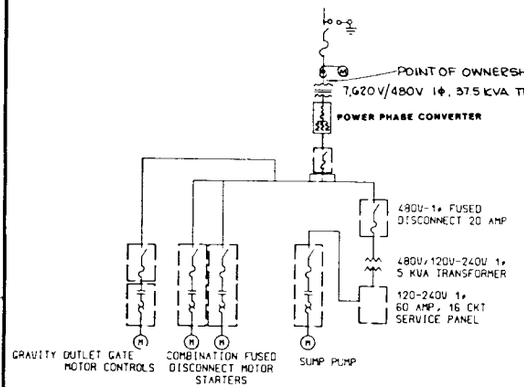
UPPER MISSISSIPPI RIVER SYSTEM
ENVIRONMENTAL MANAGEMENT PROGRAM
POOL 16, RIVER MILE 462.7
ANDALUSIA SLOUGH

WATER CONTROL STRUCTURE

Scale: AS SHOWN
Date:
Drawing Code:
Sheet reference number:
Sheet _ _ of _

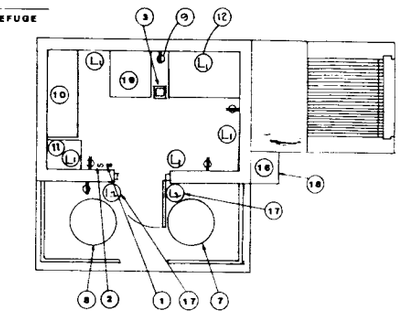
PLATE 21

ITEM	DESCRIPTION	MANUFACTURERS DATA
1	LIGHT SWITCH	
2	SUMP LIGHT SWITCH	
3	GATE OPERATOR	
7	PUMP MOTOR	
8	PUMP MOTOR	
9	RECEPTACLE (6 REQ'D)	
10	CONTROL CENTER	
11	STEEL FILE CABINET (2 DRAWER)	
12	LUMINAIRE 150W VAPOR TIGHT (5 REQ'D)	
13	LUMINAIRE 150W VAPOR TIGHT (2 REQ'D, ONE FOR EACH SUMP)	
16	FLOAT SWITCHES	
17	PHOTO-ELECTRIC CONTROL-OUTSIDE LIGHTS	
18	WALL MOUNTED 150W HPS LIGHT (2 REQ'D)	
9	SUMP PUMP (240V-1φ)	

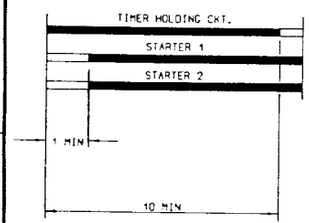


ONE LINE DIAGRAM OF PUMPING STATION POWER SERVICE

NOTE:
FUSED DISCONNECT SWITCHES FOR THE GATE OPERATOR MOTOR STARTERS TO BE IN THE CONTROL CENTER. THE MOTOR STARTER TO BE WITH THE GATE OPERATOR AND TO BE THE PROPER SIZE FOR THE MOTOR H.P. USED.



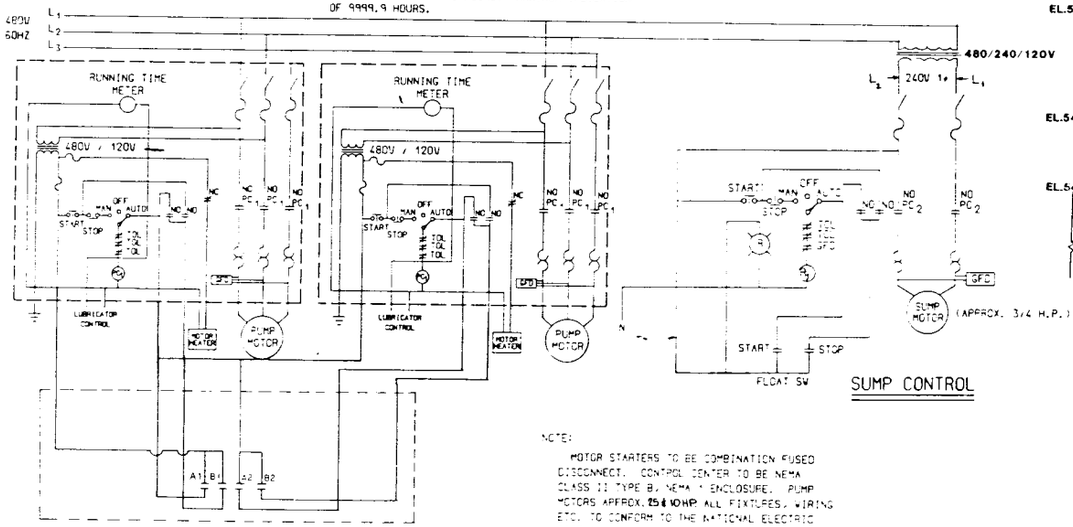
ELECTRICAL EQUIPMENT PLAN



SEQUENTIAL STARTING TIME CHART

	START	STOP
FIRST PUMP **A**	EL. **546.5**	EL. **547.0**
SECOND PUMP **B**	EL. **542.5**	EL. **542.0**

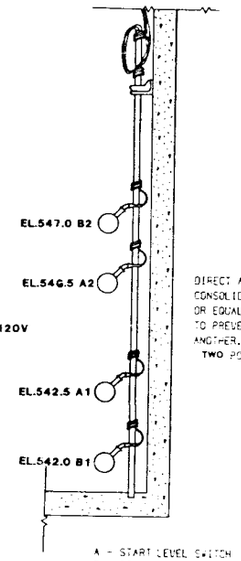
RUNNING TIME METER DIGITAL TYPE SHOWING TOTAL HOURS AND 1/10 HOURS. MAXIMUM INDICATION OF 9999.9 HOURS.



SUMP CONTROL

NOTE:
MOTOR STARTERS TO BE COMBINATION FUSED DISCONNECT. CONTROL CENTER TO BE NEMA CLASS II TYPE B, NEMA 1 ENCLOSURE. PUMP MOTORS APPROX. **15 & 10HP** ALL FIXTURES, WIRING ETC. TO CONFORM TO THE NATIONAL ELECTRIC CODE & NATIONAL ELECTRIC SAFETY CODE.

SCHEMATIC DIAGRAM OF PUMP MOTOR STARTERS AND CONTROL



DIRECT ACTING FLOAT SWITCH CONSOLIDATED ELECTRIC CO. MODEL PG OR EQUAL. FLOATS TO BE ORIENTED TO PREVENT INTERFERENCE WITH ONE ANOTHER. FLOAT B SHALL BE A TWO POLE DEVICE.

A - START LEVEL SWITCH
B - STOP LEVEL SWITCH

FLOAT SWITCHES

NOTES:
1. CONTRACTOR SHALL PROVIDE A 3" CONCRETE PAD UNDER THE CONTROL CENTER AND FILE CABINET. CONTROL CENTER TO BE TWO INCHES FROM WALLS.
2. PUMPS MAY BE RUN MANUAL START-AUTOMATIC STOP OR AUTOMATIC START-AUTOMATIC STOP.
3. LUBRICATORS SHALL BE WIRED TO OPERATE ONLY WHEN THE STORM WATER PUMPS ARE RUNNING.
4. INDICATOR LIGHTS, RED-OFF AND GREEN-ON, SHALL BE PROVIDED ON THE MCC FOR EACH STORM WATER PUMP.
5. SUMP PUMP TO BE EQUIPED WITH FLOATS FOR AUTOMATIC OPERATION. FLOATS SHALL BE SET AT STARTING EL. **539.5** AND STOPPING EL. **538.7** SUMP PUMP CAPACITY SHALL BE AT LEAST 120 G.P.M. AT 15FT. TDH.

Revisions			
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U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

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UPPER MISSISSIPPI RIVER SYSTEM
ENVIRONMENTAL MANAGEMENT PROGRAM
POOL 16, RIVER MILE 462.7
ANDALUSIA SLOUGH
ELECTRICAL
ONE-LINE DIAGRAM

Scale:
Date:
Drawing Code:
Sheet reference number:
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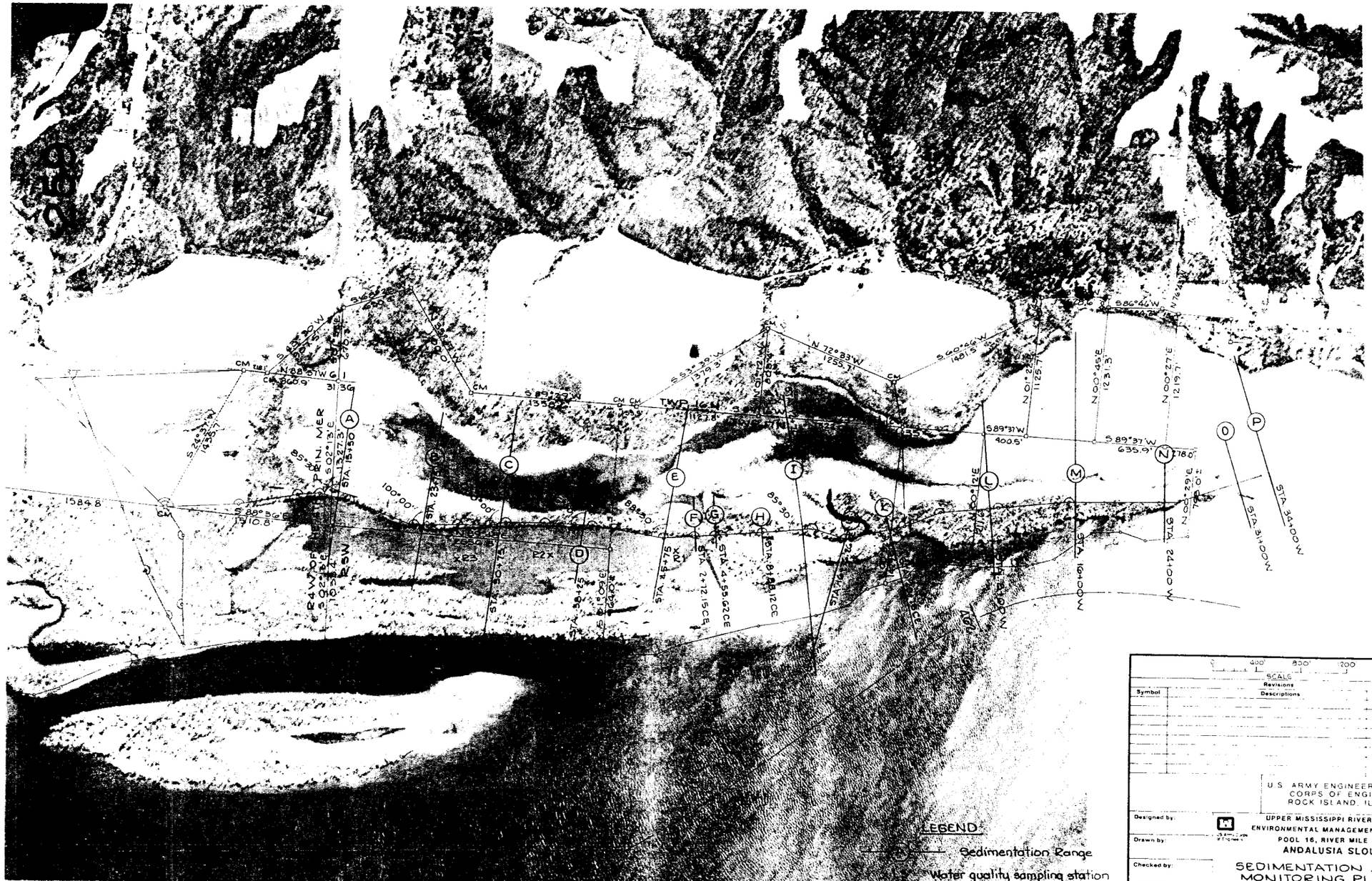
PLATE 22


LEGEND:
Sedimentation Range
Water quality sampling station
SCALE
Revisions
Symbol
Descriptions
Date
Approved
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS
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UPPER MISSISSIPPI RIVER SYSTEM
ENVIRONMENTAL MANAGEMENT PROGRAM
POOL 16, RIVER MILE 462.7
ANDALUSIA SLOUGH
SEDIMENTATION AND
MONITORING PLAN
Scale: As shown
Date:
Drawing Code:
Sheet reference number:
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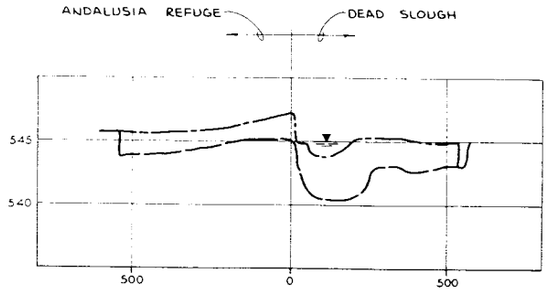
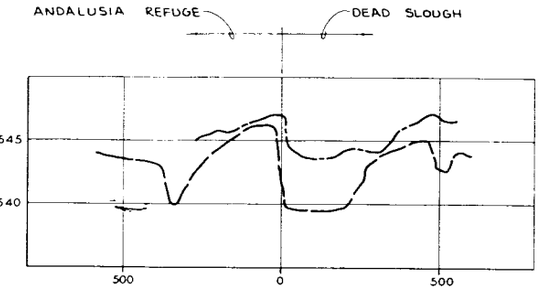
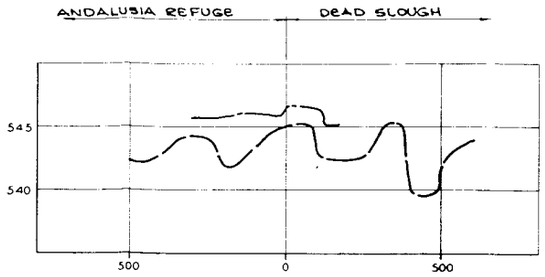
PLATE 23



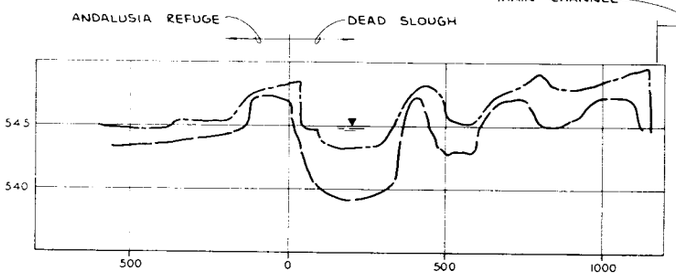
RANGE A STATION 15+50



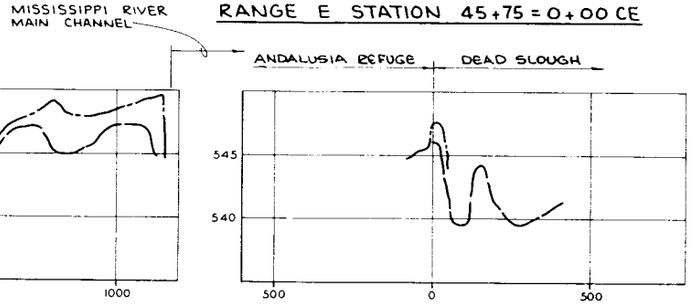
RANGE E STATION 45+75 = 0+00 CE



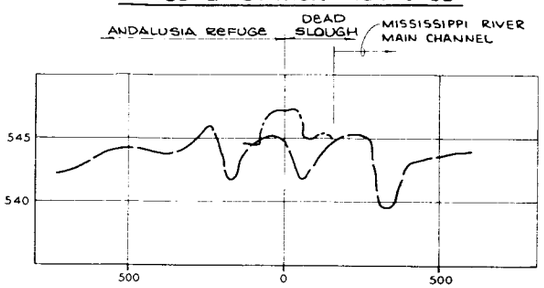
RANGE I STATION 12+70 CE



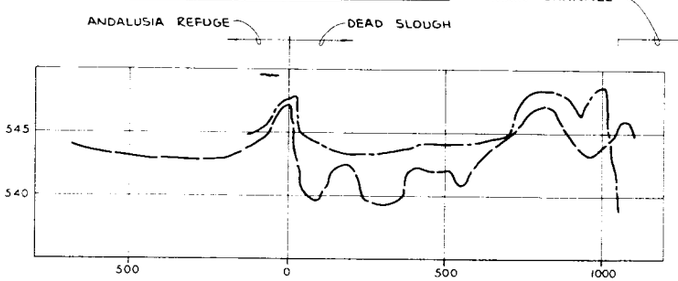
RANGE B STATION 23+75



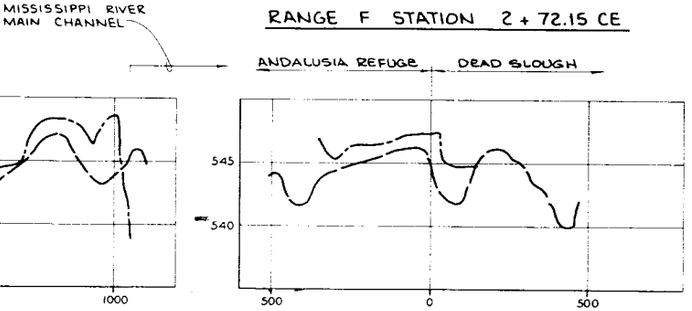
RANGE F STATION 2+72.15 CE



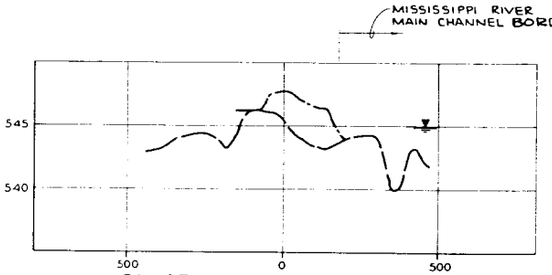
RANGE J STATION 16+76.26 CE



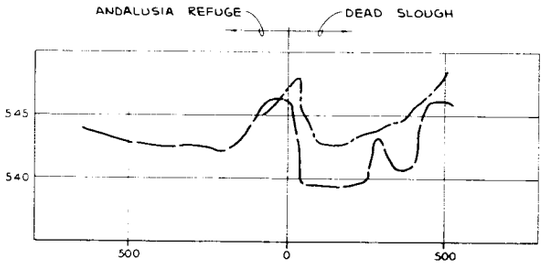
RANGE C STATION 30+75



RANGE G STATION 4+55.62 CE



RANGE K STATION 20+75 CE



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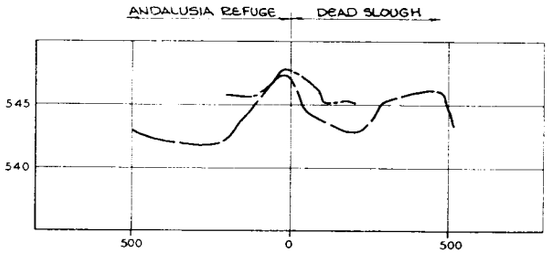


RANGE H STATION 8+88.12 CE

ELEVATION LEGEND:

- 1987, FIELD BOOK FC-87-9 AND FC-87-10
- 1936 PLANE TABLE, SHEETS 16-T-12 AND 16-T-13
- FLAT POOL ELEVATION 545.0

Revisions			
Symbol	Descriptions	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

Designed by:
Drawn by:
Checked by:
Reviewed by:
Approved by:

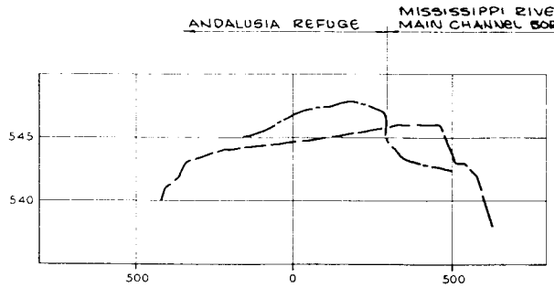
US Army Corps of Engineers

UPPER MISSISSIPPI RIVER SYSTEM
ENVIRONMENTAL MANAGEMENT PROGRAM
POOL 16, RIVER MILE 482.7
ANDALUSIA SLOUGH

SEDIMENT RANGES A THROUGH K

Scale: As Shown
Date:
Drawing Code:
Sheet reference number:
Sheet __ of __

PLATE 24



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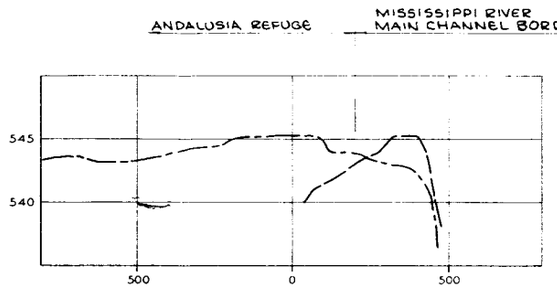

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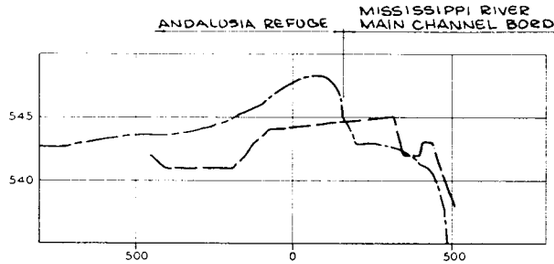

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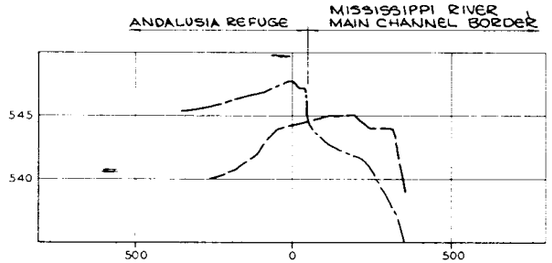

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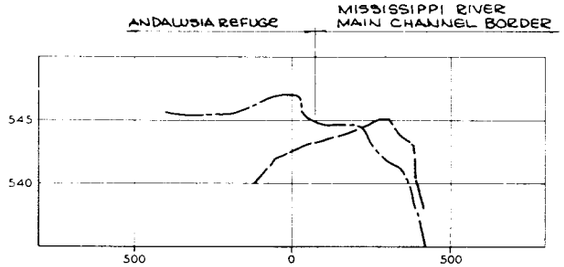


RANGE O STATION 31+00

Revisions			
Symbol	Descriptions	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

Designed by:
Drawn by:
Checked by:
Reviewed by:
Approved by:

US Army Corps of Engineers

UPPER MISSISSIPPI RIVER SYSTEM
ENVIRONMENTAL MANAGEMENT PROGRAM
POOL 16, RIVER MILE 462.7
ANDALUSIA SLOUGH

SEDIMENT RANGES L THROUGH P

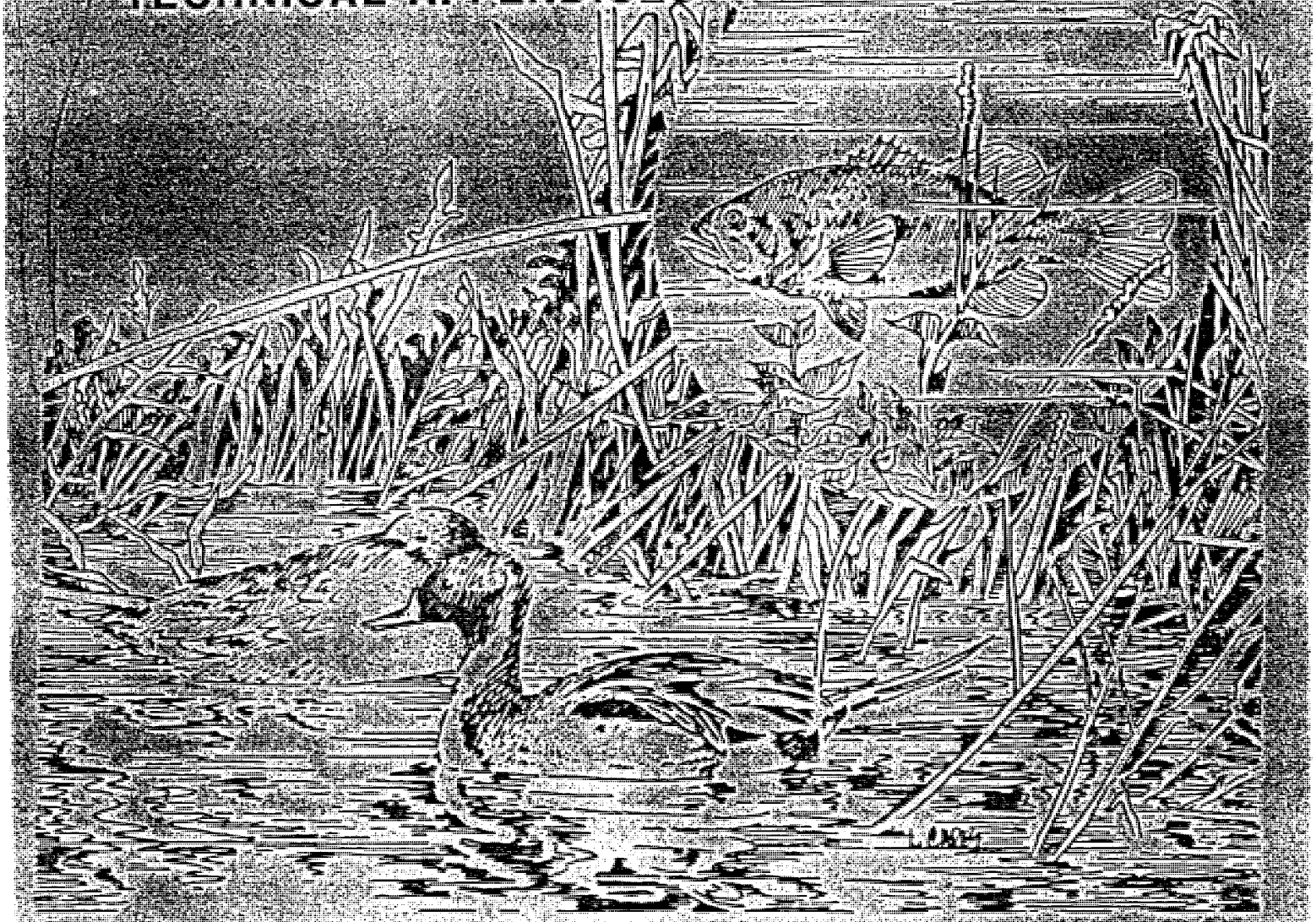
Scale: As shown
Date:
Drawing Code:
Sheet reference number:
Sheet _ _ of _

PLATE 25

UPPER MISSISSIPPI RIVER SYSTEM ENVIRONMENTAL MANAGEMENT PROGRAM DEFINITE PROJECT REPORT (R-4) WITH INTEGRATED ENVIRONMENTAL ASSESSMENT

ANDALUSIA REFUGE REHABILITATION AND ENHANCEMENT

TECHNICAL APPENDICES



NOVEMBER 1988

US Army Corps
of Engineers
Rock Island District

Pool 16
UPPER MISSISSIPPI RIVER
ROCK ISLAND COUNTY, ILLINOIS

UPPER MISSISSIPPI RIVER SYSTEM
ENVIRONMENTAL MANAGEMENT PROGRAM
DEFINITE PROJECT REPORT

ANDALUSIA REFUGE
REHABILITATION AND ENHANCEMENT

POOL 16, MISSISSIPPI RIVER MILES 462 THROUGH 463

ROCK ISLAND COUNTY, ILLINOIS

TECHNICAL APPENDICES

A - HYDROLOGY AND HYDRAULICS

B - WATER QUALITY

C - GEOTECHNICAL CONSIDERATIONS

D - STRUCTURAL DESIGN

E - HYDRAULIC DREDGING - WATER COLUMN DATA

F - MECHANICAL AND ELECTRICAL CONSIDERATIONS

G - SEDIMENTATION STUDY

H - ILLINOIS DEPARTMENT OF CONSERVATION FISHERIES INVESTIGATION OF DEAD SLOUGH

I - WATERFOWL OBSERVATION DATA FOR ANDALUSIA REFUGE

HYDROLOGY AND HYDRAULICS

UPPER MISSISSIPPI RIVER SYSTEM

ENVIRONMENTAL MANAGEMENT PROGRAM

DEFINITE PROJECT REPORT (R-4)

ANDALUSIA REFUGE

REHABILITATION AND ENHANCEMENT

POOL 16, RIVER MILES 462 THROUGH 463

ROCK ISLAND COUNTY, ILLINOIS

APPENDIX A

HYDROLOGY AND HYDRAULICS

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ENVIRONMENTAL MANAGEMENT PROGRAM

DEFINITE PROJECT REPORT (R-4)

ANDALUSIA REFUGE

REHABILITATION AND ENHANCEMENT

POOL 16, RIVER MILES 462 THROUGH 463

ROCK ISLAND COUNTY, ILLINOIS

APPENDIX A

HYDROLOGY AND HYDRAULICS

GENERAL

The Andalusia Refuge area, shown on plate 1 of the main report, is located within the Upper Mississippi Wildlife and Fish Refuge between river miles 462 and 463 in Pool 16. This area, located 1 mile north of Illinois City, is currently managed as a waterfowl refuge by the Illinois Department of Conservation.

The purpose of this appendix is to present the development and evaluation of proposed improvements which will provide a water control structure system. This system will provide a moist soil management unit with controlled water levels, reduce sedimentation into the refuge area, and divert upland sedimentation from the refuge area. Approximately 1.55 square miles of overland area will drain into the moist soil management unit. The elevation area and capacity curves for the project are shown on plate A-1.

CLIMATE

The climate in east-central Iowa is characterized by extreme temperatures and moderate precipitation. The National Weather Service operates a weather station in Moline, Illinois, located about 25 miles north of Andalusia, which has over 50 years of

record. Temperatures range from a maximum of 107 degrees Fahrenheit in the summer to a minimum of -26 degrees Fahrenheit in the winter. The normal temperature is 49.5 degrees Fahrenheit.

Most of the precipitation occurs in summer and fall months, with May, June, and July normally the wettest months, having a monthly average of over 4 inches. Winters are normally the driest parts of the year. The average annual precipitation is 37.2 inches and the average annual snowfall is 28 inches. Table A-1, shown below, lists the appropriate monthly precipitation amounts at the Moline gage for the 36 years of record during the periods 1951 to 1987.

TABLE A-1

Average Monthly Precipitation

Month	Inches	Month	Inches
January	1.64	July	4.88
February	1.30	August	3.76
March	2.77	September	3.74
April	3.97	October	2.70
May	4.21	November	2.16
June	4.32	December	1.92

HYDROLOGY

Mississippi River discharge frequency relationships and corresponding water surface profiles were promulgated by the Upper Mississippi River Basin Commission (UMRBC) in a November 1979 study entitled Upper Mississippi River Water Surface Profiles, River Mile 0.0 to River Mile 847.5. Plate A-2 presents pertinent data from this study. Actual water elevations are recorded daily at Fairport, Iowa (RM 462.0). Plates 5 and 6 of the main report show daily stage hydrographs for the period of record 1967 through 1986 (gage zero equals 535.16 feet above mean sea level (MSL). These data were used to compute monthly and year-round elevation duration relationships for the project site as presented on plates A-3 through A-6. The 50 percent duration elevation can be interpreted as the average elevation. The months of July, August, and September have the lowest normal elevations, referenced to feet above MSL, of 545.4, 545.3, and 545.3, respectively. The year round normal elevation is about 545.5 feet. Typical floods appear to last for at least 25 days and raise the water surface about 5 feet.

SEDIMENT CONDITIONS

Historical records of past sedimentation rates are essentially nonexistent. A paper by J. Roger McHenry dated March 1981 entitled "Recent Sedimentation Rates in Two Backwater Channel Lakes, Pool 14, Mississippi River" indicates widely varying deposition rates, with an average of about 0.1 foot per year. Diversion of the upland drainage from the refuge area and the proposed levee with 2-year flood protection will decrease the sedimentation rate. A detailed discussion of sedimentation is presented in Section 2 of the main report.

HYDRAULICS OF PROPOSED PROJECT CONDITION

The proposed project includes a levee constructed to provide protection from the 2-year flood event. The levee height will be 552.8 feet MSL at the most upstream end and slope to 550.8 feet MSL at the most downstream end. The levee will be tied into the natural ground elevation of 551.8 feet MSL at both ends as shown on plates 8 and 12 of the main report.

Located at the downstream end of the levee is a 600-foot armored section designed for overflow purposes. The overflow section was designed to be the area where overtopping will first occur during flood events greater than the 2-year frequency. Once overtopping of the overflow section occurs, the interior of the levee will fill before overtopping of the main levee section occurs. This will equalize the hydrostatic pressure and reduce damage during flood events greater than the 2-year frequency. The riprap for this armored section is discussed in a following section.

The area of conveyance for the 100-year flood event was computed for existing conditions and compared to that of the proposed conditions. There was approximately a 7 percent reduction in the cross-sectional area at the project site. The reduction occurs in the over bank area which does not normally convey much of the flood flow. The estimated difference in flood elevations for all floods is substantially less than 0.1 foot. A channel cross section for existing and proposed conditions is shown on plate A-7. Table A-2 lists the number of times per month the 2-year flood elevation was exceeded during the years 1965 through 1987 at the Fairport gage.

TABLE A-2

Number Of Times The 2-Year Elevation

Was Exceeded (1965-1987)

Month	Number	Month	Number
January	0	July	0
February	0	August	0
March	3	September	0
April	9	October	1
May	7	November	0
June	1	December	0

WATER CONTROL STRUCTURE

A significant aspect of the project is the upstream gated water control structure between Dead Slough and the Refuge as shown on plate 10 of the main report. The purpose of this structure is to allow river water entry into the moist soil unit during non-managed periods of the year. The unit consists of one gate well with a slide gate as shown on plate 21 of the main report. The structure was designed to fill or drain the interior with 200 acre-feet of volume in a 14-day period. It was concluded that an average head of about .5 foot will be available and an area of 1.8 square feet will be required. This will be provided with a 36-inch pipe as shown on plate 21 of the main report, resulting in an average discharge velocity of approximately 4.0 feet per second.

RIPRAP DESIGN

An 18-inch layer of riprap was designed to armor the overflow portion of the levee. The overflow levee will be used in flood events to back water into the refuge area. During the initial stages of overtopping, the overflow section will have water overtopping in free flow, which is considered the most critical time for stability. For floods greater than the 2-year event, the project levee will be in a submerged state and less likely to be damaged.

Routing a typical Mississippi River flood through the overflow portion of the levee resulted in a maximum head of approximately 0.55 foot above the levee crest prior to submergence. Technical

Report NO. 2-650 "Stability of Riprap and Discharge Characteristics, Overflow Embankments, Arkansas River, Arkansas" was referenced in order to determine the stability of the overflow section. The data in this report did not cover small head elevations above the crest. However, interpolation of the data would result in the overflow section being borderline unstable if unprotected.

The overflow portion of the levee is located in a north-south direction and will be exposed to expected wind velocities as high as 70 miles per hour. In accordance with CETN-I-6 "Revised Methods for Wave Forecasting in Shallow Water," it was determined that 2.5-foot waves could be caused as a result of wind velocities, fetch, and depth of water at the project area. Due to the possible unstable condition of the overflow levee and the possible wave attack, a minimum 15-inch layer of riprap was determined to be required to armor the levee. This was based on a density 165 pcf which results in a D50 of .58 feet. However, as discussed in Appendix C - Geotechnical Considerations, based on experience 18-inch thick riprap will be provided for adequate protection during all overflow scenarios. The minimum required riprap design gradation was determined in accordance with procedures in EM 1110-1601 and ETL 1110-2-120. The following is the required minimum and the recommended gradations for the riprap:

Percent Lighter by Weight	Limits of Stone wt., lbs.	
	Minimum	Recommended
100	170-70	150-400
50	50-35	60-170
15	25-10	15-50

The riprap blanket should extend beyond the toe of the bank. A bedding layer 6 inches thick should be provided under the riprap.

Riprap protection is also recommended at the upstream gated water control structure. A horizontal blanket of riprap will be provided to prevent scour during the worst case scenario for which the velocities could be as high as 12 feet per second. This is based on assumed conditions including incorrect operation of the gate, involving opening it with low pond conditions during a 2-year flood event on the river. The required riprap blanket was determined in accordance with procedures in Research report H-70-2, "Erosion and Riprap Requirements at Culvert and Storm-Drain Outlets." The riprap blanket, as shown on plate 21 of the main report, will be 18 inches thick with a D50 of .58 foot. The minimum and recommended riprap gradation are the same as shown above for the overflow portion of the levee.

PUMP SIZE

Another significant aspect of the project is the pump station located at the downstream end of the levee as shown on plate 12 of the main report. The station will be a two pump system with the capability to pump into the river from the moist soil unit during desirable periods and will also have the capability to pump from the river into the moist soil unit during low river events to ensure adequate water depth during critical periods. The effects of normal rainfall, seepage, evaporation, and upland drainage were all considered in the pump design.

One pump was designed with the capability to pump from the refuge area in order to drawdown the refuge from flat pool elevation 545 (MSL) to approximately 543.5 (MSL) within 14 days. This will be accomplished by a 5,000 gallons per minute (gpm) pump. Alternative pump sizes studied were 10,000 and 2,000 gpm. The 10,000 gpm pump would enable the refuge operator to draw down the refuge within 14 days during periods of extended high flow without utilizing gravity flow. The 2,000 and 5,000 gpm pump would utilize gravity flow to draw the refuge area down to elevation 545 feet (MSL) and then complete the drawdown to elevation 543.5 feet (MSL) within 14 days. The time increment for gravity flow from overflow elevation of 550.8 (MSL) to flat pool elevation of 545 (MSL) would depend upon river flood recession. A typical Mississippi River flood will recede approximately .5 foot per day. The Refuge area will drop at about the same rate as the river. Therefore pumping should not be initiated until the flood event passes and normal levels of approximately 545 to 546 (MSL) occur. Operating in this manner is economically consistent with a low operating budget, and meets Refuge objectives. The 5,000 gpm pump was the selected alternative based on being most economical within the desired 14-day drawdown period. The 2,000 gpm pump would require longer running time and would limit the flexibility of the Refuge operator.

The second pump was designed with the capability to raise and maintain the water elevation within the levee from elevation 545 feet (MSL) to 547.0 feet (MSL) within 10 days. This will be provided by a 3,500 gpm pump. A smaller pump would require a longer time to fill the interior and larger size would be unnecessary for typical operating procedures. Table A-3 lists the number of pumping days required to raise the water level within the MSMU to selected elevations from flat pool elevation of 545 feet (MSL). The pumping days shown are conservative estimates because average rainfall was not considered. Studies indicate that evaporation during typical pumping periods is negligible.

TABLE A-3

PUMPING DAYS REQUIRED

FOR 3500 GPM PUMP

ELEVATION ft. (MSL)	PUMPING DAYS
546	3.5
547	9.5
548	17
549	28
550	43
550.8	55

DIVERSION DITCH DESIGN

The drainage ditch shown on plate 8 of the main report was diverted because of the objective of reducing upland erosion sedimentation from entering the project site. The ditch has a 1.8-square-mile drainage area and was designed for a discharge of 340 cubic feet per second, which is approximately the 2-year frequency flood and is consistent with the existing ditch capacity. The ditch cross section should have a 30-foot bottom width and 3:1 side slopes. A profile slope of .0025 ft./ft. was designed to match existing profile conditions as close as possible, as shown on plate 16 of the main report. A design flood will result in an average velocity of approximately 3 feet per second.

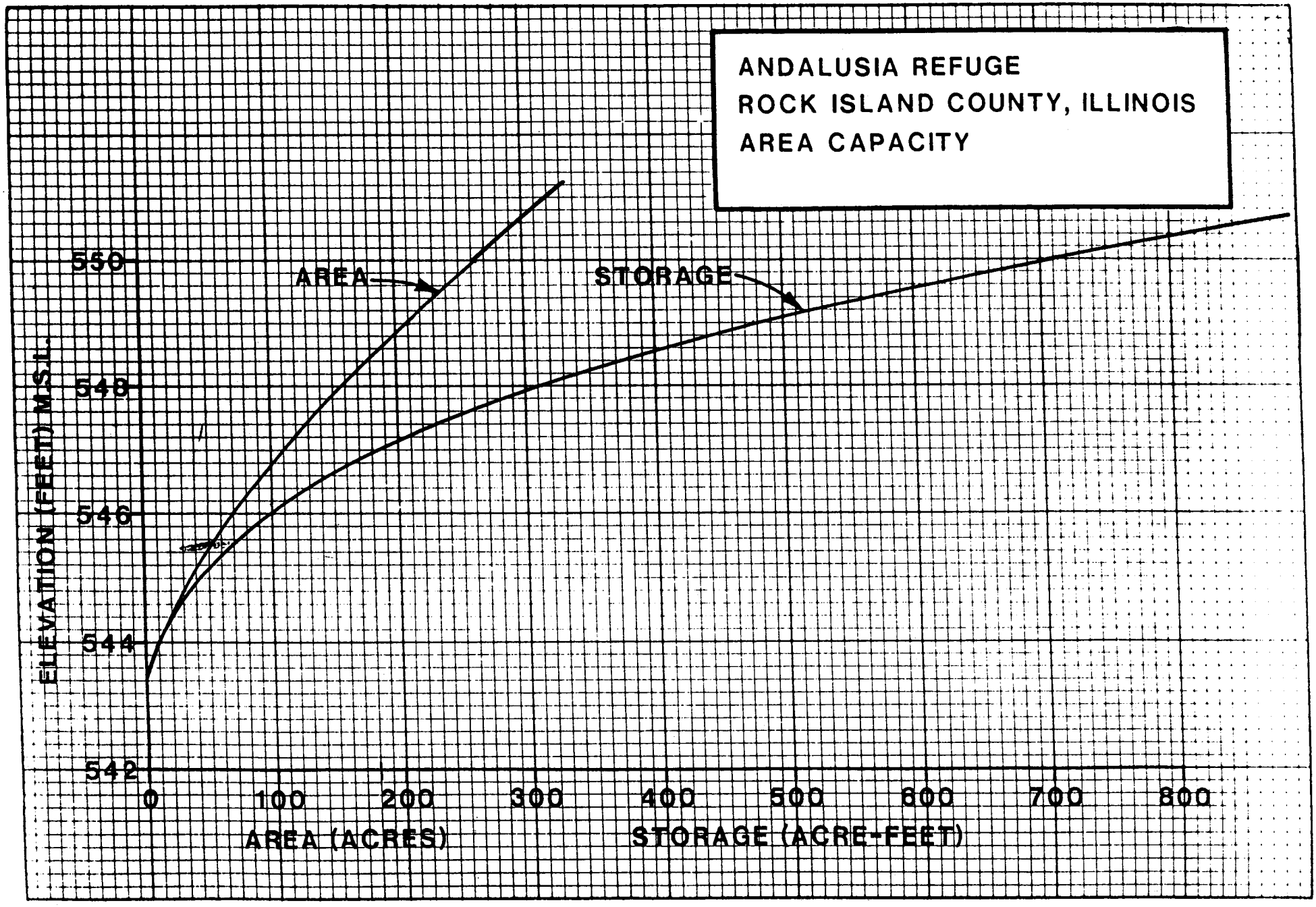
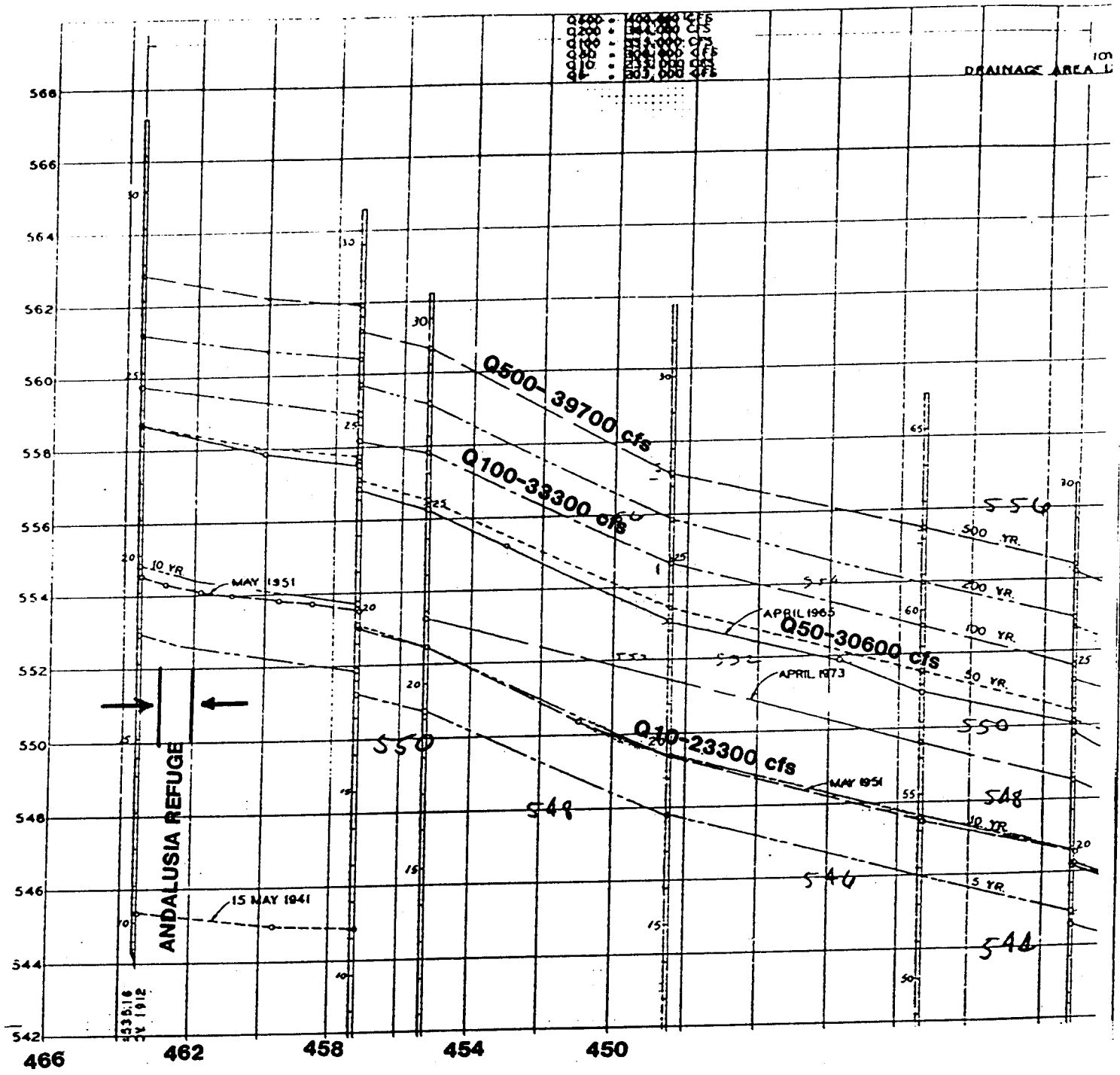

ANDALUSIA REFUGE
ROCK ISLAND COUNTY, ILLINOIS
AREA CAPACITY
AREA
STORAGE
550
548
546
544
542
ELEVATION (FEET) M.S.L.
0
100
200
300
400
500
600
700
800
AREA (ACRES)
STORAGE (ACRE-FEET)

PLATE A-1



REVISION	DATE	DESCRIPTION	BY

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DISTRICT ENGINEER
ROCK ISLAND, ILLINOIS

DRAWN BY: GEH
TRACED BY:
CHECKED BY: JNS
SUBMITTED:
CHIEF HYDRAULICS BRANCH
APPROVED:
CHIEF, ENGINEERING DIVISION
DATE:

UPPER MISSISSIPPI RIVER
STANDARD FLOOD PROFILES
ROCK ISLAND DISTRICT

5, 10, 50, 100, 200, & 500 YEAR FLOOD

RIVER MILES 518.52 TO 463.5

PLATE A-2

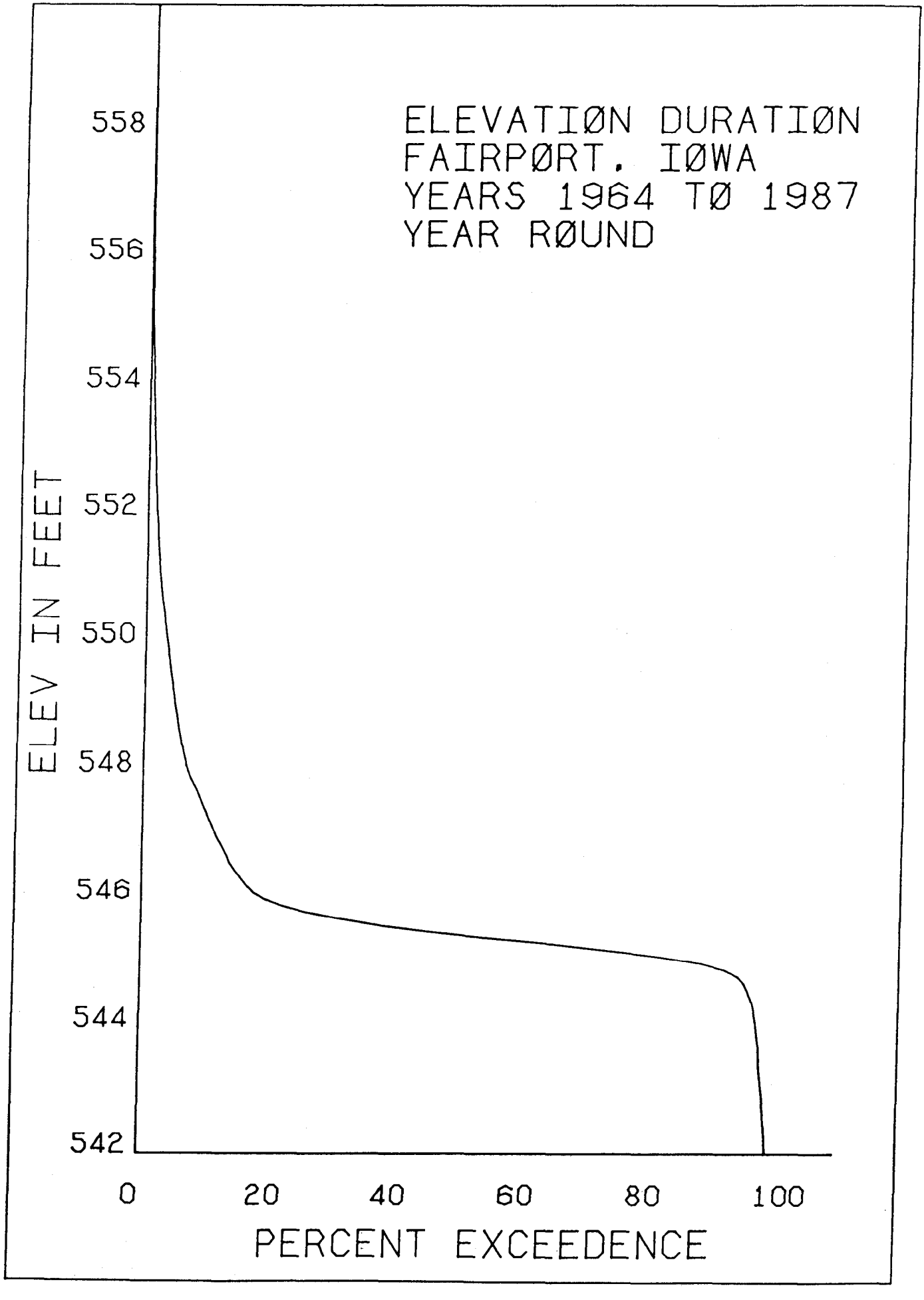
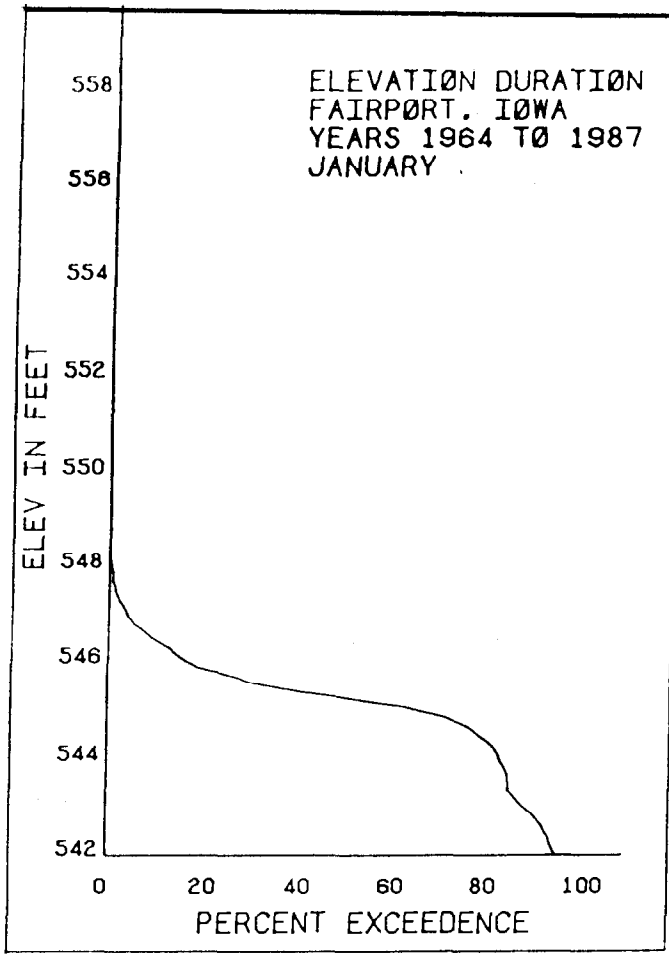
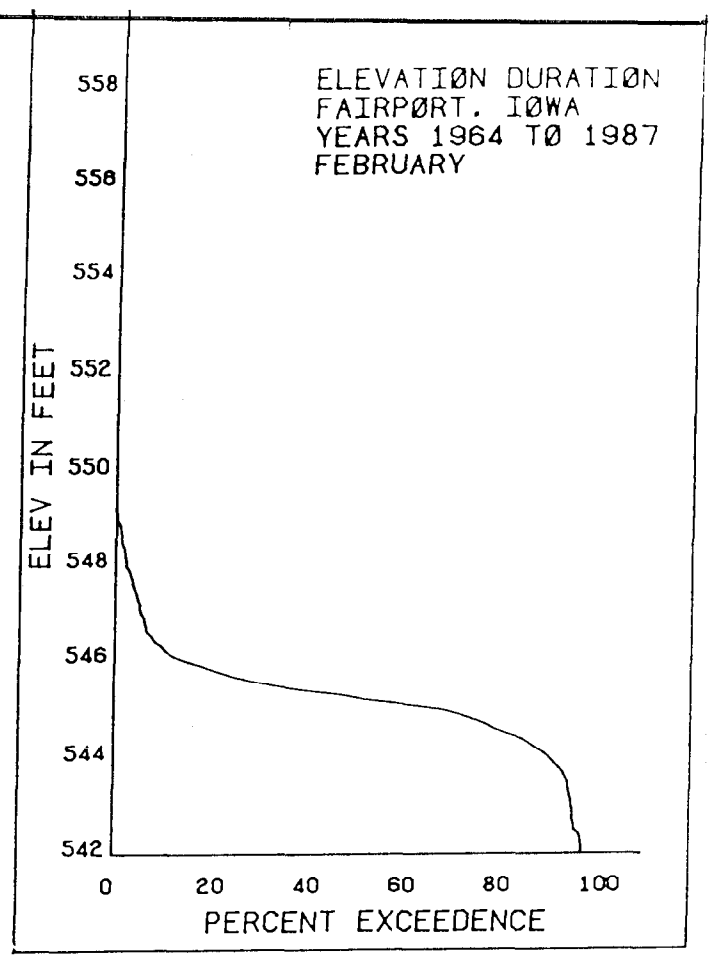
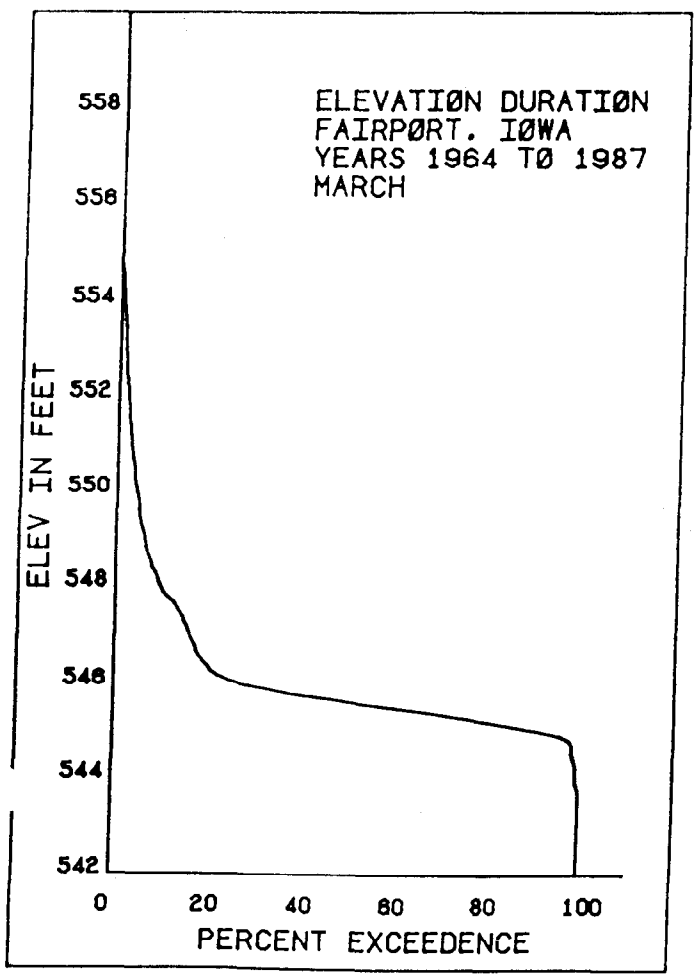

ELEVATIØN DURATIØN
FAIRPØRT. IØWA
YEARS 1964 TØ 1987
YEAR RØUND
ELEV IN FEET
558
556
554
552
550
548
546
544
542
0
20
40
60
80
100
PERCENT EXCEEDENCE

PLATE A-3


ELEVATIØN DURATIØN
FAIRPØRT. IØWA
YEARS 1964 TØ 1987
JANUARY
ELEV IN FEET
558
556
554
552
550
548
546
544
542
0
20
40
60
80
100
PERCENT EXCEEDENCE


ELEVATIØN DURATIØN
FAIRPØRT. IØWA
YEARS 1964 TØ 1987
FEBRUARY
ELEV IN FEET
558
556
554
552
550
548
546
544
542
0
20
40
60
80
100
PERCENT EXCEEDENCE


ELEVATIØN DURATIØN
FAIRPØRT. IØWA
YEARS 1964 TØ 1987
MARCH
ELEV IN FEET
558
556
554
552
550
548
546
544
542
0
20
40
60
80
100
PERCENT EXCEEDENCE

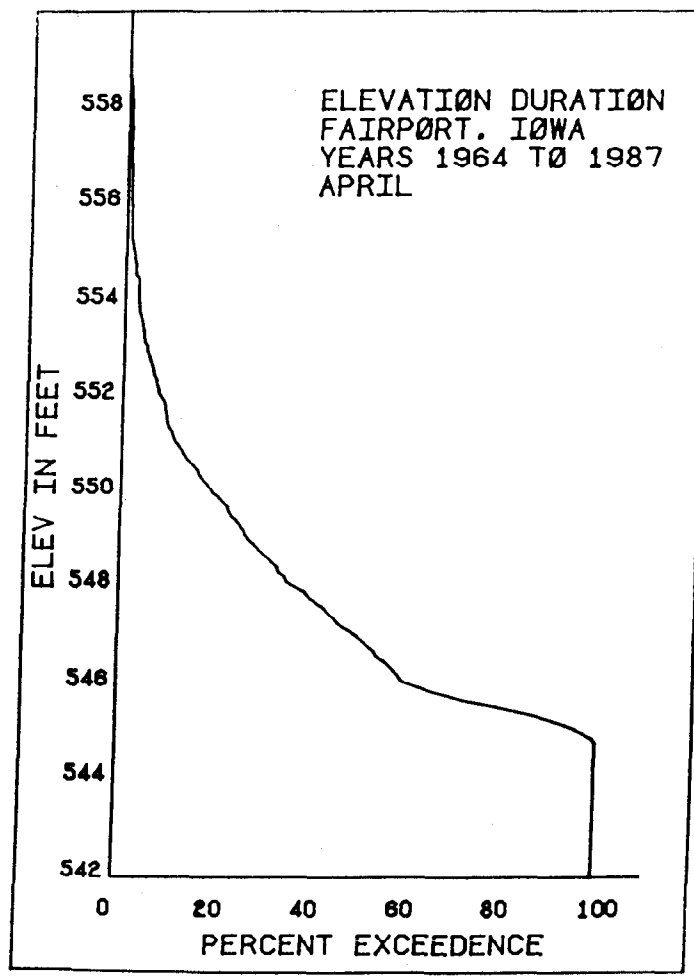
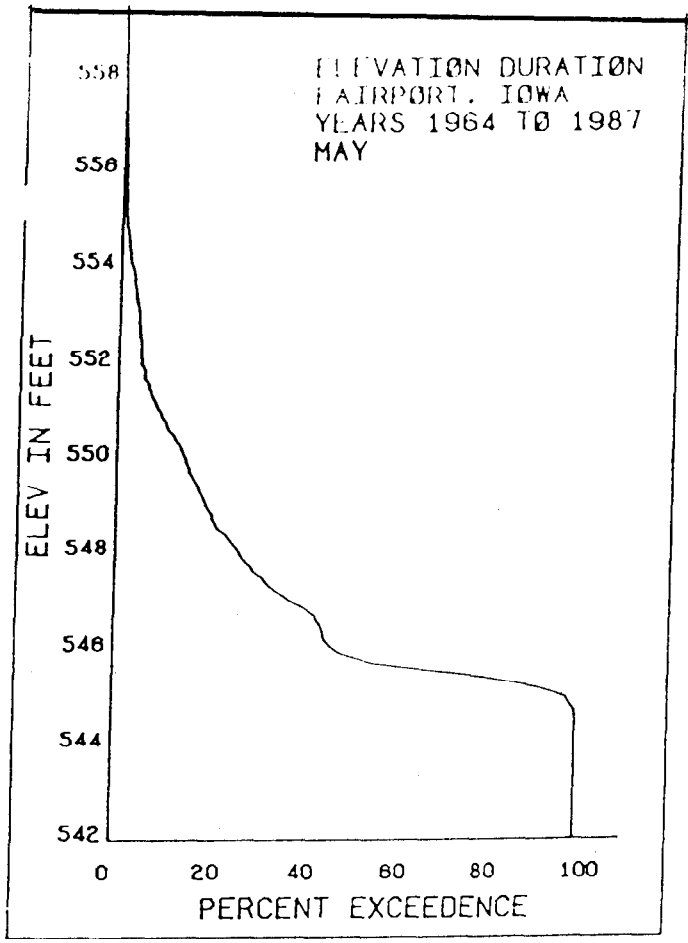
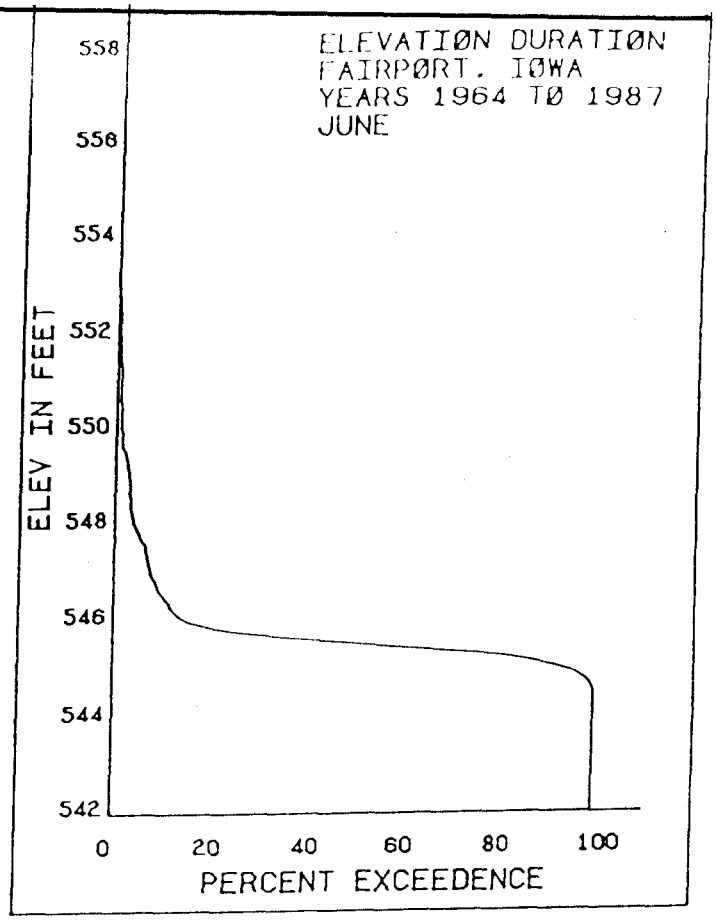
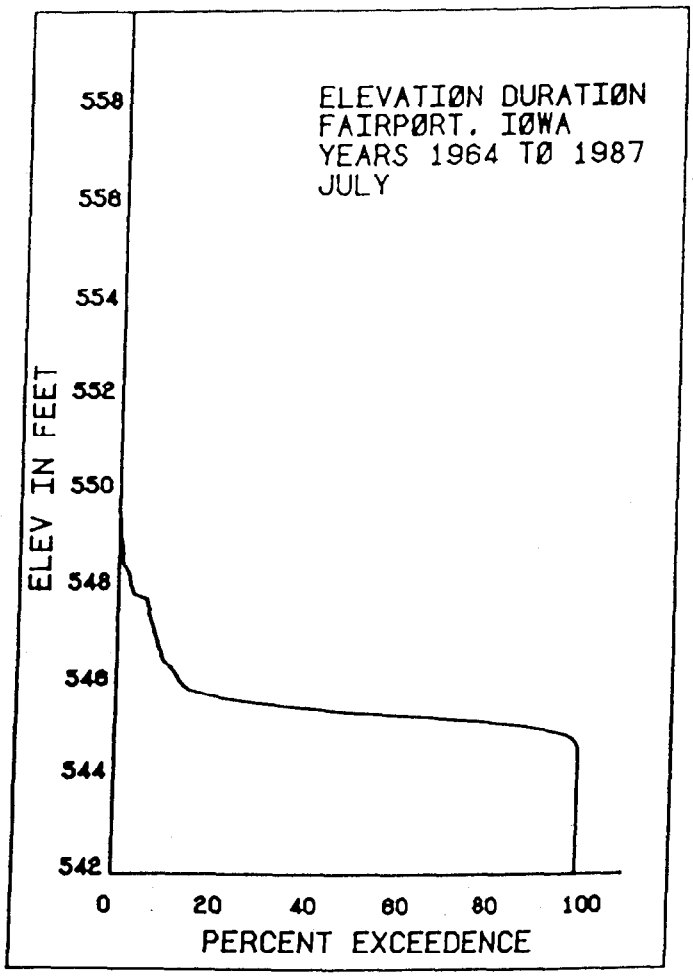

ELEVATIØN DURATIØN
FAIRPØRT. IØWA
YEARS 1964 TØ 1987
APRIL
ELEV IN FEET
558
556
554
552
550
548
546
544
542
0
20
40
60
80
100
PERCENT EXCEEDENCE

PLATE A-4


ELEVATIØN DURATIØN
FAIRPØRT. IØWA
YEARS 1964 TØ 1987
MAY
ELEV IN FEET
558
556
554
552
550
548
546
544
542
0
20
40
60
80
100
PERCENT EXCEEDENCE


ELEVATIØN DURATIØN
FAIRPØRT. IØWA
YEARS 1964 TØ 1987
JUNE
ELEV IN FEET
558
556
554
552
550
548
546
544
542
0
20
40
60
80
100
PERCENT EXCEEDENCE


ELEVATIØN DURATIØN
FAIRPØRT. IØWA
YEARS 1964 TØ 1987
JULY
ELEV IN FEET
558
556
554
552
550
548
546
544
542
0
20
40
60
80
100
PERCENT EXCEEDENCE

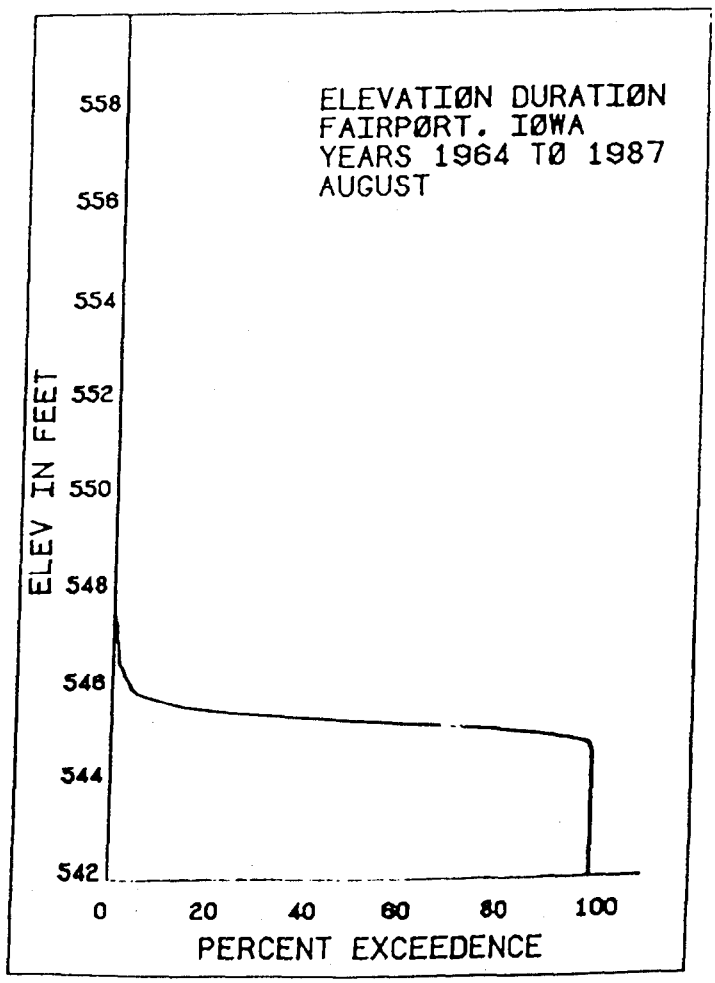
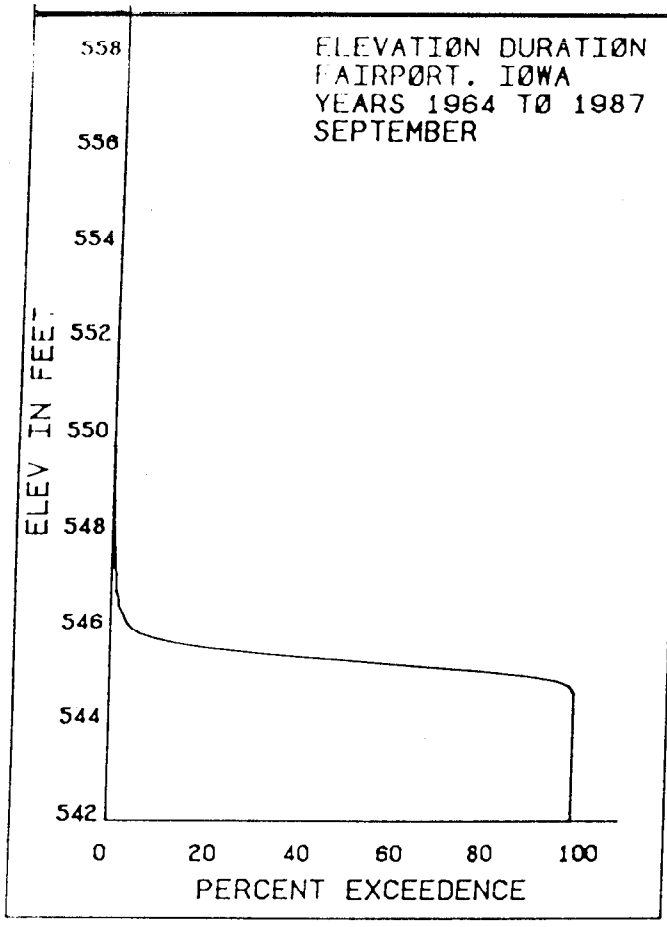
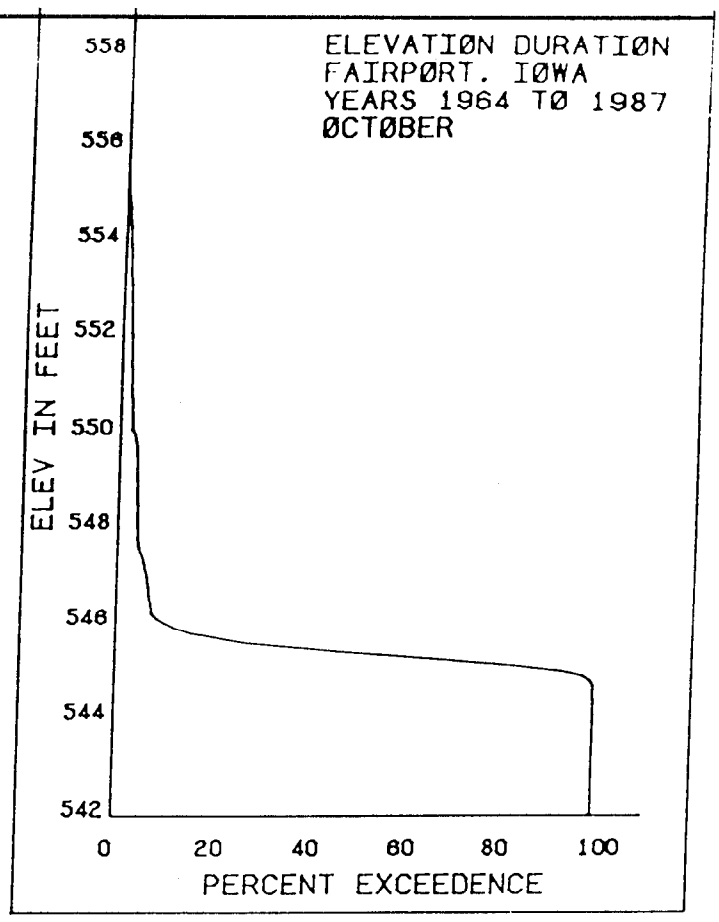

ELEVATIØN DURATIØN
FAIRPØRT. IØWA
YEARS 1964 TØ 1987
AUGUST
ELEV IN FEET
558
556
554
552
550
548
546
544
542
0
20
40
60
80
100
PERCENT EXCEEDENCE

PLATE A-5


ELEVATIØN DURATIØN
FAIRPØRT. IØWA
YEARS 1964 TØ 1987
SEPTEMBER
ELEV IN FEET
558
556
554
552
550
548
546
544
542
0
20
40
60
80
100
PERCENT EXCEEDENCE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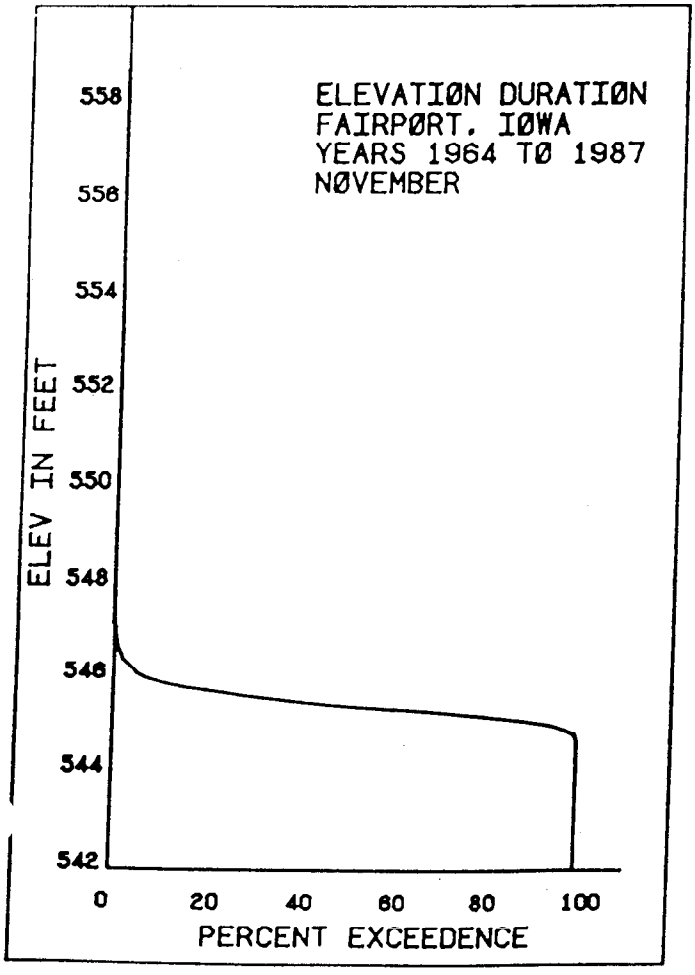
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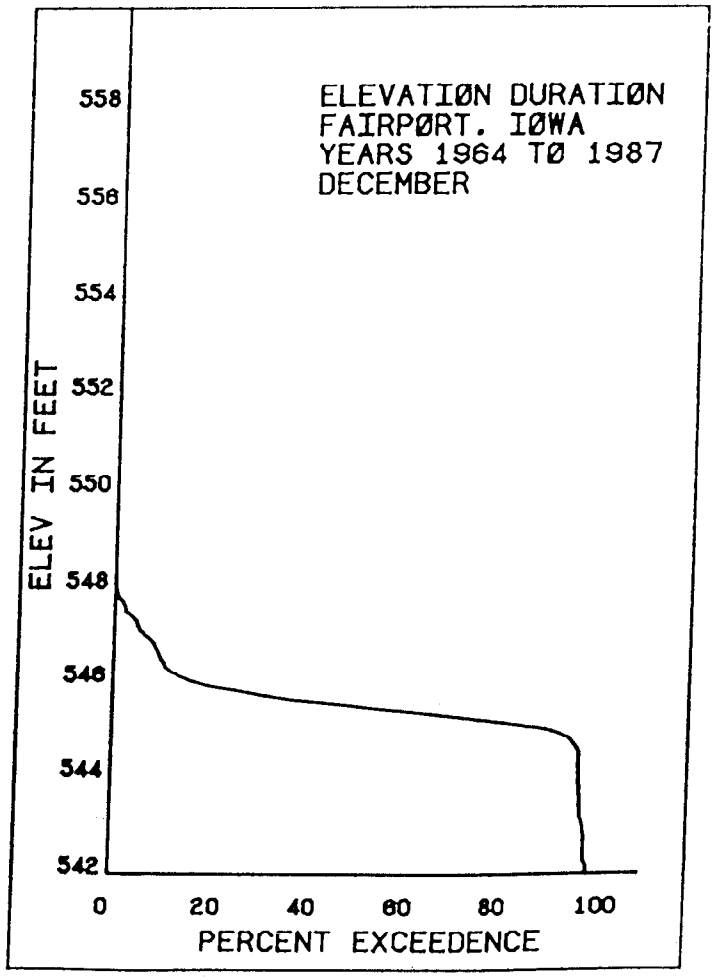
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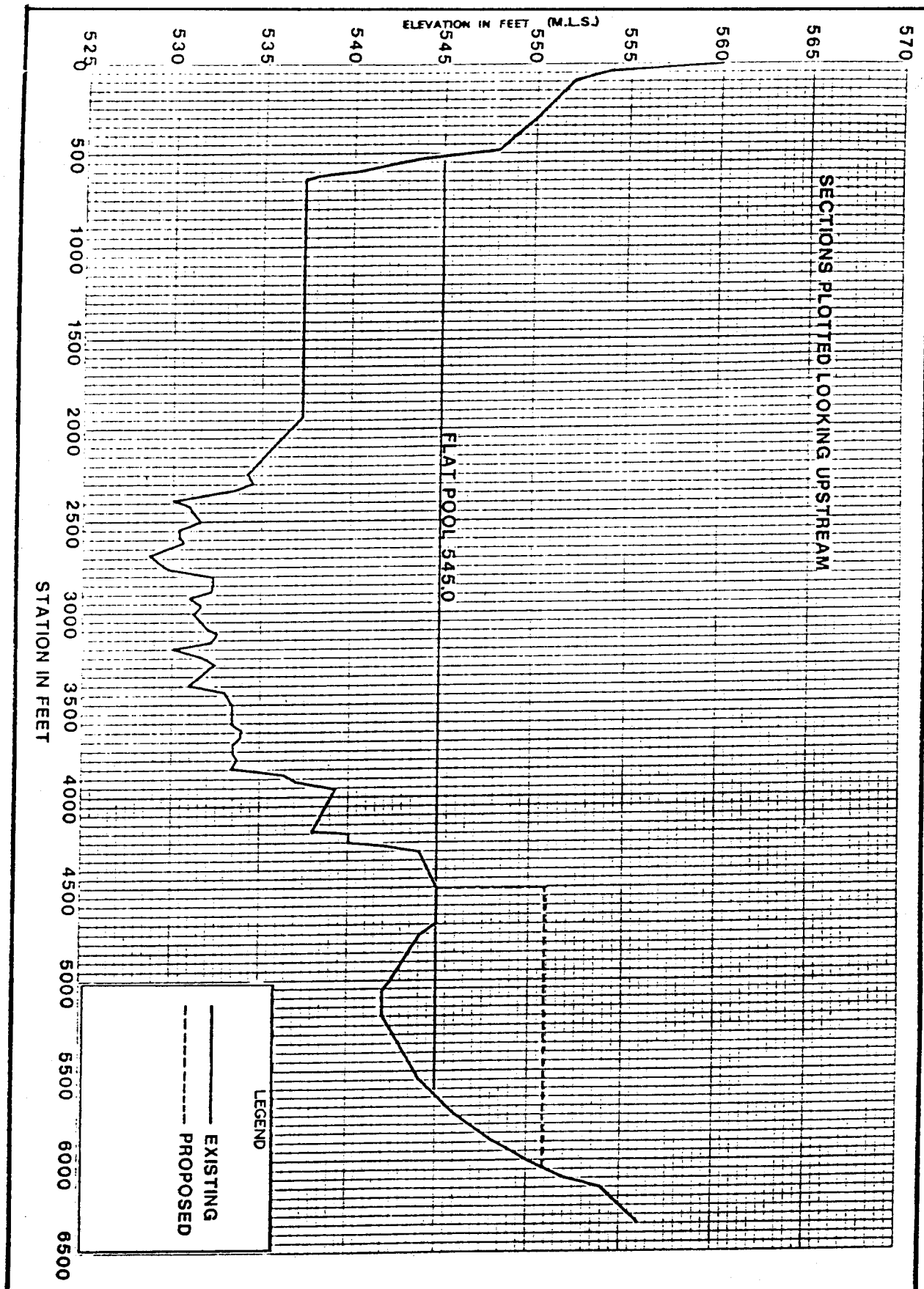
PERCENT EXCEEDENCE

PLATE A-6



ANDALUSIA REFUGE

CHANNEL SECTION AT RIVER MILE 462.0

MISSISSIPPI RIVER

PLATE A-7

APPENDIX B

WATER QUALITY

UPPER MISSISSIPPI RIVER SYSTEM
ENVIRONMENTAL MANAGEMENT PROGRAM
DEFINITE PROJECT REPORT (R-4)

ANDALUSIA REFUGE REHABILITATION AND ENHANCEMENT

POOL 16, MISSISSIPPI RIVER MILES 462 THROUGH 463
ROCK ISLAND COUNTY, ILLINOIS

APPENDIX B
WATER QUALITY

OVERVIEW

Several water quality related factors bear on the suitabliity of the backwater complex to support valuable aquatic and semi-aquatic species. These include the chemical composition of the water, the chemical and physical composition of the sediment, and the depth and availability of water throughout the year. Representatives of the Iowa Department of Natural Resources (DNR) indicated that water quality within Andalusia Slough is currently adequate to support the native fisheries during the summer months. However, under ice cover, conditions develop which result in periods where dissolved oxygen (D.O.) becomes depleted to the point where fish kills can occur. In fact, fish kills have been observed on several occasions during the early spring immediately after ice out. Although it is not known with certainty that the cause of these fish kills is low D.O., it is reasonable to assume that it is at least a contributing factor. As the entire backwater area is heavily laden with aquatic vascular plants during the summer months, it is easy to envision the decomposition of this organic material during the winter leading to low D.O. levels.

In order to assess the existing water quality situation and predict the impacts of any enhancement efforts, a monitoring program was initiated in 1987. Water samples were taken every 2 weeks during the summer and less frequently during the remainder of the year. In addition, sediment and elutriate samples were collected. These data provide the basis for the assessment of water quality within the study area.

METHODS

Ambient water samples were collected on eight occasions between January and September 1987. An attempt to collect samples was made on two other occasions, however, insufficient water depth existed to permit taking representative samples. On January 28, 1987, samples were taken from the ice at locations R2 and R3

shown on plate 23 of the main report. On seven occasions, samples were taken from boat at the single location A1 shown on plate 23. Due to the shallow water and abundant aquatic plant growth, it was not possible to collect samples during the summer from the immediate project area. The location selected was as close to the project site as water conditions would allow. Due to the lack of significant flow through the backwater area and the relative proximity of the winter and summer sampling locations, it is quite likely that little, if any, difference in water quality exists between the sampling sites. In all cases, grab samples were taken from immediately below the surface using a Kemmerer sampler. Field analyses (temperature, pH, D.O., specific conductance and secchi disk depth) were performed immediately, while the samples requiring laboratory analysis were appropriately preserved, placed on ice, and shipped the same day they were collected.

Sediment and elutriate samples were taken at six locations on August 12, 1988. The locations are shown on plate 23 and coincide quite closely with the locations of the surface samples collected on January 28, 1987. Locations R1 - R3 were taken using a 48-inch coring device. The resulting cores were between 24 and 36 inches in length. At locations L1 - L3, no water was present and the soil was quite dry and compacted. Samples at these locations were taken using a shovel and were from the upper 1 to 2 feet of the soil. All water samples taken for the purpose of preparing the elutriate samples were collected and handled in the manner described above. All sediment samples were placed on ice and shipped to the laboratory the same day they were collected.

Grain size analyses were performed in accordance with U.S. Army Corps of Engineers, Engineer Manual 1110-2-1906, Appendix V, November 1970. Chemical analyses were performed according to "Standard Methods for the Examination of Water and Wastewater," 16th Edition, American Public Health Association, Washington, D.C., 1985. Elutriate samples were prepared by mixing 1 part sediment with 4 parts ambient water, shaking for 30 minutes, and allowing 4 hours to settle.

RESULTS

Results of all field and laboratory analyses are presented in tables B-1 through B-4. Table B-1 lists the results of grain size analyses of samples collected on June 21, 1988. It is apparent from the results that the sediment is very fine throughout the backwater area. For a complete hydrometer analysis, see appendix C. Table B-2 lists the results of all laboratory and field tests performed on ambient water samples. From the results it can be seen that D.O. concentrations are low during several weeks of the observation period. While levels do not fall below 4.0 mg/l, they approach this level and probably do

fall below this level during the night. The chlorophyll concentrations indicate that phytoplankton are quite abundant at certain times and probably contribute to fluctuations in D.O. concentrations.

Even though samples were taken some distance from the actual project location due to access problems, water depth was still quite shallow and was barely adequate to permit reaching this point by boat. This was true despite the fact that the river was at or above flat pool each day that samples were collected.

Table B-3 lists the results of bulk sediment analyses performed on samples collected on August 12, 1988. As can be seen from the data, all inorganic contaminants except total volatile solids fell in the range considered to be nonpolluted based on EPA's draft criteria for Great Lakes sediment. Total volatile solids undoubtedly exceeded the criteria due to the large amount of detritus present in the sediments. There is no evidence of large concentrations of soluble organic contaminants as seen from the fact that all pesticide concentrations were below the detection limits.

Table B-4 lists the results of elutriate analyses performed on samples collected on August 12, 1988. As can be seen from the data, concentrations of most parameters were quite low. The only exception to this is ammonia nitrogen. Concentrations were observed which exceeded the general water quality standards at two locations. All pesticide concentrations were below the detection limits.

CONCLUSIONS

Based on field observations and analytical results, water quality within the project area appears adequate to support aquatic life during the majority of the time. During the summer there may be periods when D.O. approaches levels considered to be detrimental to certain fish species. This was observed during the study period, although no fish kills were observed. During the winter there may be ice and snow conditions, which, in combination with decayed organic matter, could develop into a "winter kill." Although this was not observed during the study period, it has been reported by DNR personnel. Results from the analyses of sediment and elutriate samples show no excessive concentrations of contaminants as compared with interim EPA criteria for Great Lakes Sediment and the State water quality standards, with the exception of ammonia nitrogen. Concentrations of this parameter should be viewed in light of the proposed mixing zone, and, if necessary, toxic effects can be minimized by coordinating construction with those periods when water temperature and pH are low.

TABLE B-1

Grain Size Analyses

Location	Percentage Passing a #230 Sieve (<0.062um)
1L	98.2
1R	99.7
2L	93.6
2R	98.2
3R	83.6
3L	82.5

TABLE B-2

Ambient Water Quality Results, 1987

Parameter	Date 1/28	1/28	6/8	6/22	7/6	7/20	8/10	8/24	9/8	9/21
	Location R3	R2	A1	A1	A1	A1	A1	A1	A1	A1
Time	1030	1045	1030	1020	1025	0925	1055	1055	1025	1205
Ice Thickness (cm)	12.5	12.5	-	-	-	-	-	-	-	-
Water Temp. (C)	-	-	25.0	26.7	26.7	27.8	24.4	20.0	21.7	15.6
Depth (M)	.3	.5	.9	.8	.7	.6	.6	.7	.8	.7
D.O. (mg/l)	15.4	23.2	6.9	4.3	5.7	6.6	4.4	4.7	4.5	4.9
pH (units)	-	-	7.6	7.2	7.2	7.6	7.3	7.4	7.0	7.2
Sp. Cond. (umhos/cm)	-	-	436	472	408	381	410	381	475	369
Secchi Depth (M)	-	-	1.5	2.0	2.0	2.0	2.0	2.0	2.5	2.0
Sus. Solids (mg/l)	-	-	24	15	10	9	4	3	4	3
Chl. a (mg/cu m)	-	-	46	12	14	6	7	10	8	5
Chl. b (mg/cu m)	-	-	2	2	2	2	2	2	1	1
Chl. c (mg/cu m)	-	-	4	2	2	2	2	2	1	1
Pheo. a (mg/cu m)	-	-	18	13	6	8	4	4	4	2

TABLE B-3

Bulk Sediment Analyses, August 12, 1988 (mg/kg)

Parameter	Location					
	R1	R2	R3	L1	L2	L3
Arsenic (Total)	2.0	2.7	1.8	2.7	4.0	2.9
Barium (Total)	74	67	62	98	88	94
Cadmium (Total)	<0.87	<0.69	<0.82	<0.79	<0.79	<0.68
Chromium (Total)	12	13	12	17	19	13
Copper (Total)	11	11	11	16	17	15
Lead (Total)	6.3	6.3	5.2	17	17	15
Mercury (Total)	<0.019	<0.027	<0.025	<0.031	<0.026	<0.026
Nickel (Total)	15	12	11	20	25	18
Selenium (Total)	<0.87	<0.69	<0.83	<0.79	<0.79	<0.68
Zinc (Total)	67	64	63	91	94	78
Ammonia-N	120	82	89	41	41	37
Total Organic Carbon	7.5%	6.9%	7.7%	8.2%	8.3%	7.9%
Oil and Grease	50	190	190	110	250	360
Total Volatile Solids	9300	19500	13200	12600	4200	13300
Aldrin	<8.0 *	<8.0 *	<8.0 *	<8.0 *	<8.0 *	<8.0 *
Chlordane	<80 *	<80 *	<80 *	<80 *	<80 *	<80 *
DDD	<16 *	<16 *	<16 *	<16 *	<16 *	<16 *
DDE	<16 *	<16 *	<16 *	<16 *	<16 *	<16 *
DDT	<16 *	<16 *	<16 *	<16 *	<16 *	<16 *
Dieldrin	<16 *	<16 *	<16 *	<16 *	<16 *	<16 *
Endrin	<16 *	<16 *	<16 *	<16 *	<16 *	<16 *
Heptachlor	<8.0 *	<8.0 *	<8.0 *	<8.0 *	<8.0 *	<8.0 *
Hepachlor Epoxide	<8.0 *	<8.0 *	<8.0 *	<8.0 *	<8.0 *	<8.0 *
Lindane	<8.0 *	<8.0 *	<8.0 *	<8.0 *	<8.0 *	<8.0 *
Methoxychlor	<80 *	<80 *	<80 *	<80 *	<80 *	<80 *
Toxaphene	<160 *	<160 *	<160 *	<160 *	<160 *	<160 *
2,4-D	– *	– *	– *	– *	– *	– *
2,4,5-TP	– *	– *	– *	– *	– *	– *
Total PCB's	<160 *	<160 *	<160 *	<160 *	<160 *	<160 *

* ug/kg

TABLE B-4

Elutriate Results from August 2, 1988, Sampling (mg/l)

Parameter	Location						Ambient Water
	L1	L2	L3	R1	R2	R3	R2
Arsenic	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.012
Barium	0.07	0.08	0.08	0.01	0.09	0.10	0.07
Cadmium	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Chromium	<0.009	<0.009	<0.009	0.01	<0.009	<0.009	0.03
Copper	<0.009	<0.009	<0.009	<0.009	<0.009	<0.009	<0.009
Lead	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Mercury	<0.0001	<0.0001	<0.0001	<0.0001	<0.0002	<0.0001	<0.0001
Nickel	<0.025	<0.025	0.03	0.12	0.06	0.03	0.03
Selenium	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Zinc	0.03	0.09	0.11	0.11	0.09	0.11	0.04
Ammonia-N	4.2	2.4	2.9	15	18	0.13	0.13
Total Vol Solids	530	450	420	580	640	420	300
Oil and Grease	4.0	16	6.0	<2.0	32	<2.0	-
TOC	48	47	16	1100	50	42	13
Aldrin*	<0.10	<0.10	<0.15	<0.10	<0.10	<0.05	<0.05
Chlordane*	<1.0	<1.0	<1.5	<1.0	<1.0	<0.50	<0.50
DDD*	<0.20	<0.20	<0.30	<0.20	<0.20	<0.10	<0.10
DDE*	<0.20	<0.20	<0.30	<0.20	<0.20	<0.10	<0.10
DDT*	<0.20	<0.20	<0.30	<0.20	<0.20	<0.10	<0.10
Dieldrin*	<0.20	<0.20	<0.30	<0.20	<0.20	<0.10	<0.10
Endrin*	<0.20	<0.20	<0.30	<0.20	<0.20	<0.10	<0.10
Heptachlor*	<0.10	<0.10	<0.15	<0.10	<0.10	<0.05	<0.05
Heptachlor Epoxide*	<0.10	<0.10	<0.15	<0.10	<0.10	<0.05	<0.05
Lindane*	<0.10	<0.10	<0.15	<0.10	<0.10	<0.05	<0.05
Methoxychlor*	<1.0	<1.0	<1.5	<1.0	<1.0	<0.50	<0.50
Toxaphene*	<2.0	<2.0	<3.0	<2.0	<2.0	<1.0	<1.0
2,4-D*							
2,4,5-TP*	=	=	=	=	=	=	=
Total PCB's*	<2.0	<2.0	<3.0	<2.0	<2.0	<1.0	<1.0

* Concentrations of all organics are expressed as ug/l.

GEOTECHNICAL CONSIDERATIONS

APPENDIX C

UPPER MISSISSIPPI RIVER
ENVIRONMENTAL MANAGEMENT PROGRAM
DEFINITE PROJECT REPORT

ANDALUSIA REFUGE
REHABILITATION AND ENHANCEMENT
POOL 16 MISSISSIPPI RIVER MILES 462 THROUGH 463
ROCK ISLAND COUNTY, ILLINOIS

APPENDIX C
GEOTECHNICAL CONSIDERATIONS

TABLE OF CONTENTS

List of Plates

LOCATION

The Andalusia EMP Project is situated within the Upper Mississippi Wildlife and Fish Refuge, between river mile 462 and 463. The site is bordered by Dead Slough directly to the north, forested loess-covered bluffs to the south, which are part of 393 acres managed by the State of Illinois, Department of Conservation. The major part of Andalusia Slough continues to the east; and Drury Slough to the west. The project area lies within the Galesberg Plain section of the Central Lowlands Province.

PHYSIOGRAPHY

The topography within the project site consists of a series of sloughs and shallow backwater lakes. Site elevation varies from 546-548 feet MSL (Mean Sea Level). Land surface configuration was originally controlled by the shape of the underlying bedrock surface. The Mississippi River valley is constricted from Andalusia to Muscatine with little or no flood plain. At the point of the project site, the valley is only about 1-1/4 miles wide. The area is known as the lower part of the "upper narrows" (Savage 1921). This narrowing is caused by the unusual thickness of Pennsylvanian age sandstone which the river runs across. On the valley walls, the erosional slopes are concealed by a mantle of unconsolidated material derived from slumping and landslides over underlying Pennsylvanian age shales.

The presence of more resistant bedrock is indicated by the steep lower slopes of the valley bedrock. Maximum relief of valley sides adjacent to the project site is 100-150 feet (Horberg 1956b).

BEDROCK

The bedrock of the project area consists of Pennsylvanian age sandstones, shales, and coals, setting unconformably on top of Devonian age shale and limestones (Fitzgerald 1985). Middle Devonian age limestones outcrop 10 miles upstream in Buffalo, Iowa and in the near by town of Andalusia, Illinois. These rocks are almost horizontal and in general slope toward the southwest at an average rate of 10 feet per mile. Overall the Devonian age rocks are about 140 feet thick. There is a Middle Devonian age shale lying directly beneath a thick section of Pennsylvanian age rocks at Wyoming Hill, and outcrop about a mile downstream from the project site on the Iowa side of the river. Overall the Pennsylvanian age rocks are up to 150 feet thick; but at Wyoming

Hill, along highway 22, NE 1/4, Sec. 34, T77N, RIW, (Horberg 1956b), the outcrop is about 100 feet thick, and consists of sandstones shales, and coals.

PLEISTOCENE AND RECENT DEPOSITS

Above, and to some extent within the Mississippi River, and tributary valleys are deposits of Pleistocene drift or till, loess, terrace deposits, recent alluvium, and dune deposits. Maximum thickness of these deposits do not exceed 100 feet around project area (Savage 1921)(Horberg 1956b). Pleistocene deposits resulted from the numerous advances and retreats of glaciers which blanketed this entire area. A road cut 4 miles upstream from the project site at Loud Thunder Forest Preserve, SW 1/4, SE 1/4, Sec. 27, TT7N, R4W, exposes 43 feet of Pleistocene sediments. The outcrop includes 23 feet of Pre-Illinoian age tills, 8 feet of Illinoian age tills, and 12 feet of Wisconsinan age, Peorian loess (Horberg 1956b).

In the Mississippi River valley at the mouth of the adjacent watersheds, the sediments consists of alluvial deposits. These alluvial deposits are unconsolidated glacial outwash sands and gravels on bedrock, with deposits of alluvial silts and clays on top. The outwash sands and gravels are of the Henry formation of Wisconsinan age, overlain by Cahokia alluvial silts and clays, Wisconsinan or Holocene in age (Willman 1970). Thicknesses of alluvial deposits along the Mississippi River from Le Claire, Iowa to Muscatine, Iowa usually varies from 15 to 45 feet (Savage 1921). At the project site, borings were drilled no futher than 30.5 feet and bedrock was not encountered.

SUBSURFACE EXPLORATIONS

Access to the project site was limited by surface water. During February 1987, eight primary borings A-87-1 through A-87-8 were taken. Borings A-87-1, 2, 5, 6, and 7 were obtained by hand with a 4-inch Iwan Auger. Borings A-87-3, 4, and 8 were obtained with a CME-45 drill rig using a 5-inch hallow stem auger.

During January and February 1988, fourteen additional exploratory borings were taken. These numbered A-88-1 through A-88-14. Holes A-88-6 and A-88-8 were obtained by using 4-inch Iwan hand auger. The other holes were obtained using CME-45 drill rig. Locations of the borings and boring logs are show on plate 2 of the main report. The deepest boring taken with the drilling rig extended to a depth of 30.5 feet, approximate elevation 517.8 feet MSL.

PERIMETER LEVEE EMBANKMENT

The proposed perimeter levee as shown on plate 2 of the main report, is approximately 6 feet high, and approximately 8,600 feet long. The purpose of the levee is to create a moist soil management unit with controlled water levels for wildlife habitat on the landside of the levee. The crown of the levee will be at least 12 feet wide for ease of construction and normal maintenance and operation. The side slopes of the levee will be 1 vertical (V) on 4 horizontal (H). From station 12+00 to 8+00 CE, the proposed levee will be wider (60-foot wide) compared to other reaches of the levee. This portion of the levee will be built with clay borrowed from the Dead Slough excavation. The majority of the excavated material from Dead Slough will be placed in the adjacent levee as a thicker, instead of transporting it to a disposal site. The typical cross sections of the proposed levee are shown on plate 18 of the main report.

From station 12+21 C to station 25+18±CE, the side slopes of the levee will be grass seeded since a heavy timber growth is evident on both sides of the proposed levee. Therefore, it is anticipated that grass protection will be adequate against wave wash. From stations 25+18±CE to 29+18±CE, the profile of the levee will be placed on a steeper gradient than the natural river flood profile to ensure overtopping occurs from the downstream end. Therefore, both side slopes of the levee will be protected against the wave wash and current action by an 18-inch thickness of riprap with the following gradation:

Percent Lighter by Weight	Weight of Stone in Pounds
100	150-400
50	60-170
15	15- 50

A similar gradation used on various similar installations has served satisfactorily for several years. A bedding layer of 6-inch thickness will be of the following gradation:

U.S. Standard Sieve Size	Percentage Passing (By Weight)
1 - 1/2	85 - 100
3/4	40 - 85
3/8	15 - 45
No. 4	0 - 20
No. 8	0 - 5

The entire levee will be built with uncompacted impervious material lie, (ie, fill place by casting).

FOUNDATION FOR EMBANKMENTS

The entire foundation beneath the proposed levee embankment will be stripped of vegetation and other deleterious materials to a depth of 6 inches. All top roots, lateral roots, and trees within the embankment foundation areas will be removed to a depth of 3 feet below natural ground surface.

An extensive field investigation was made to ascertain the proposed levee foundation conditions. According to borings which were pertinent to approximately 6 feet high perimeter levee foundation analyses, the foundation material consists of alluvial deposits. Boring logs are shown on plate 7 of the main report. The top stratum varies in thickness from 16 to 20 feet, and consists of normally consolidated impervious alluvial deposits (SC, CL, CL-CH, and CH). The moisture content ranges from 24 to 37 percent for CL soils, 27 to 35 for CL-CH soils, and 29 to 48 for CH soils. Borings A-88-8, A-88-9, and A-88-14 show that the top 1-foot consists of slightly organic clay with moisture content of 85 percent.

The Atterberg limits testing was performed on the selected soil samples after throughly evaluating each soil sample. Atterberg limits testing reveals a range from 44/16 (liquid limit/plastic limit) to 44/18 for CL soils, 55/21 to 58/22 for CL-CH soils, and 71/28 to 82/29 for CH soils. The standard penetration test "N" values recorded during the drilling operations for top stratum ranged from 2 to 9 blow counts, with average "N" values of 6. The shear strength of the top stratum based on standard penetration tests varies from 250 psf to 1,125 psf with an average of 750 psf. The pocket penetrometer tests were also run on the selected clay samples. The pocket penetrometer tests indicate a range in cohension from 250 to 1250 psf.

The soils below the impervious substratum are found to be medium to fine sand (SP). The "N" values obtained for the sand ranged from 4 to 23, with average "N" values of 11. Detailed descriptions of the encountered materials are shown on boring logs, on plate 7 of the main report. None of these borings were extended to bedrock.

FOUNDATION FOR OTHER STRUCTURES

A water control structure near station 21+00 will be built as a part of the proposed project. The location of the proposed structure is shown on plate 2 of the main report. Boring A-88-3, 32 feet deep was taken to evaluate physical characteristic of subsurface conditions. Detailed descriptions of soils encountered are shown on boring logs, see plate 7 of the main report. The boring does not show undesirable or soft material.

The unsuitable material which might not have been encountered by this boring will be replaced with appropriate fill. The replacement material will be placed and compacted to obtain a density equal to the adjacent undisturbed foundation. A dewatering system will be required to maintain the excavation area in dry condition. Foundation design details of the proposed structures are given in Appendix D.

Borings have not been completed due to site change location of pump plant. Therefore, two additional borings will be taken prior to final design to determine engineering properties of the soils underlying the pump station foundation.

GROUNDWATER

Water level observations were monitored during the boring operations and are noted on the boring log as shown on plate 7 of the main report. Based on these observations the ground water levels encountered in the vicinity of the proposed embankment area approximately from station 4+00 to 21+50 were found to be fairly consistant from hole to hole. The depth at which water was located ranged from 2 to 3 feet; from elevations 544.5 to 545.5 feet MSL. From approximately stations 21+50CE to 31+00CE (end of the levee) the ground water was found to be .2 to 1 foot above the ground surface; from elevations 545 to 546 feet MSL. The water levels should be expected to fluctuate with changes in climatic conditions and river levels.

SUBSURFACE CONDITIONS AT EXCAVATION SITES

REFUGE DREDGING/DITCHING. Refuge excavation/ditching is proposed as shown on plate 18 of the main report. The site indicates removal of 2 to 4 feet of soils, which will have a width of 50 feet. Borings A-87-4, A-88-2, and A-88-13 were taken to identify the subsurface conditions and the engineering characteristics of the encountered material at the proposed site.

Borings revealed the presence of about 4 feet of very soft clay (CH-OH, CL, CH). The moisture content varied from 43% to 71%. This is underlain by medium clay (CL-CH). The moisture content varied from 32% to 37%. A detailed description of the encountered material is shown in the logs of soil borings on plate 7 of the main report.

DEAD SLOUGH EXCAVATION. Dead slough site will be located approximately 40 feet from riverside toe of the proposed levee as shown on plate 18 of the main report. The site indicates the need for removal of 6 to 9 feet of soils, which will have a width of 60 feet. Borings A-88-10 and A-88-11 were considered pertinent taken to determine the various soil profile components and the engineering characteristics of the material for dredging the dead slough. A typical soil profile of this site consists of very soft clay. The average water content was 98 percent, with a range of 98 to 107 percent. A detailed description of the encountered materials is shown on the logs of soil borings on plate 7 of the main report.

SLOPE STABILITY

The proposed levee near station 28+50 CE is found to be most critical for slope stability analysis for end of construction condition. The stability of slopes was analyzed by the Modified Swedish Method for a circular Arc Slope Stability Analysis in accordance with EM 1110-2-1902, "Engineering Design Stability of Earth and Rockfill Dams," dated 1 April 1970.

A sudden drawdown and steady seepage conditions were not evaluated since high water levels will be of such short duration that saturation of uncompacted impervious embankment cannot occur and the Mississippi River low water level will not impose any seepage pressure on the levee.

A range of extremely conservative shear strengths (Q) was assumed for the most severe configuration of embankment and foundation, to estimate the stability of the embankment. These valves are shown on plate C-1 and are based on tests and samples from other projects with generally similar soils and construction. Successive trails of various sliding surfaces were analyzed and determination of the critical failure arc having the lowest safety factor was made. The summary of the slope stability analysis and the solution of the most critical arc appears on plate C-1. The computed minimum, safety factor of 2.3 for end of construction condition exceed the 1.3 required by EM 1110-2-1913, "Design and Construction of Levees," dated March 31, 1978. Therefore, no slope stability problems are expected.

UNDERSEEPAGE

The underseepage analyses for the proposed is based on a thorough study of thickness and permeability, engineering characteristics of the impervious stratum and the pervious substratum, in addition to the extent of the riverward and landward top strata.

Case 2 (EM 1110-2-1913)-Impervious Top Stratum Both Riverside and Landside was considered appropriate since 15- to 20-foot thick top stratum appears to exist on the both sides of the approximately 6 feet high levee, and continuing infinitely on the landward side. For such a condition seepage will not occur through the landside top stratum; therefore, underseepage and berm analyses were not made.

SETTLEMENT

The proposed levee, from approximately station 23+00CE to 30+18CE is found to be most critical with respect to settlement. A study at station 28+50 was selected for analysis, where the levee is approximately 7 feet high.

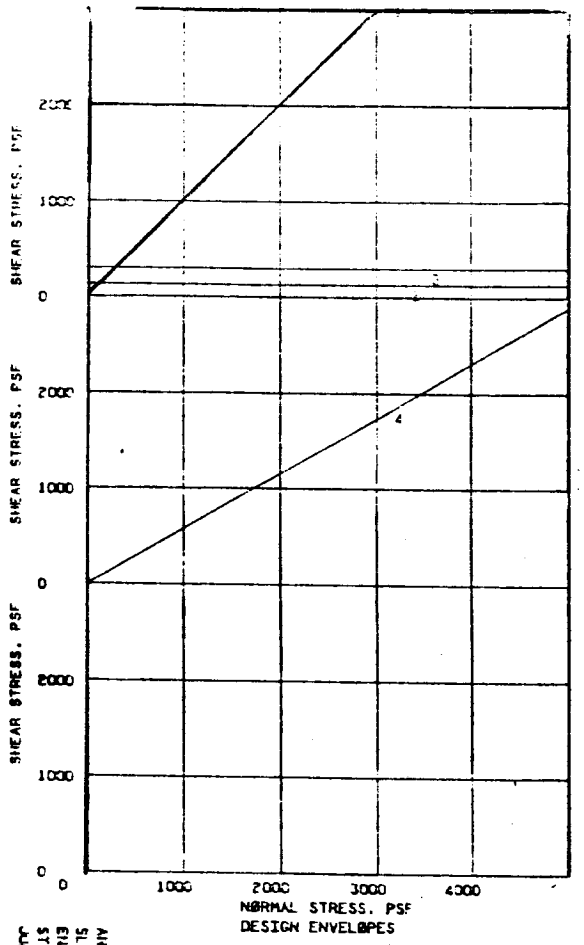
The foundation, in this reach of the levee consists of a 1-to 2-foot thick layer of very soft organic clay. The soil below the soft clay consists of clay of a higher shear strength and a low compressibility. It is anticipated that the very soft clay will be displaced during the construction of the levee by stronger fill material. Therefore, a 9-foot high levee is considered appropriate for the settlement analysis. The 9-foot high levee will impose a maximum load of 810 pounds per square foot on the 15-foot-thick alluvial clay top stratum foundation. A settlement analysis conforming to Joseph E. Bowles "Foundation Analysis and Design," 3rd edition, 1982, indicates total settlement to be on the order of 14 inches, as shown on plate C-3. In order to anticipate the unexpected settlement, a shrinkage allowance of 24 percent of the levee height will be provided in the specifications to allow for any consolidation of the embankment and settlement in the foundation.

BORROW MATERIAL

The borrow material will be removed from areas as shown on plate 18 of the main report. The source of the borrow site location was determined to be as close as adjacent to the levee toe. A 40-foot width berm will be left in place between the toe of the levee and near the edge of borrow site to ensure levee stability and to facilitate construction. According to borings which are pertinent to borrow areas, the borrow material consist of very wet soft clay, exceeding the liquid limit. The moisture content varies from 43 to 107 percent. Atterberg limits testing reveals a range from 71/28(liquid limit/plastic limit) to 82/29. These borrow areas are economically feasible source of material to construct the uncompacted levee. Because it involves a short

or no haul distance and is conducive to dragline operation. Due to the soft nature of the borrow soils, care will be required in excavation and placement to insure the soils will stay in place on the slopes.

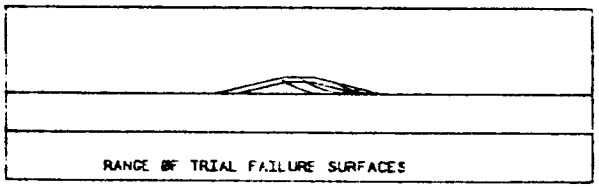
A dragline will be used to excavate and place the material. Excessive displacement of the excavated material should be expected due to very soft material of low strength and standing water. The material placement will require gentle laying of the excavated material from bottom to top to minimize the disturbance. The excavated material will be left inplace for a period until it regains strength. The excavated material will not be stockpiled higher than the height of the proposed embankment or the embankment will be constructed in multiple stages.



MATERIAL		SOIL WT. LBS/CUFT		SHEAR STRENGTH - S (R-S) / E							
		MOIST	SAT	PHI DEGREES	COHESION PSF	PHI DEGREES	COHESION PSF	PHI DEGREES	COHESION PSF	PHI DEGREES	COHESION PSF
RIPRAP AND BEDDING ELEV 544 TO 551	1	100.00	100.00	45.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CLAY EMBANKMENT ELEV 544 TO 548	2	80.00	80.00	0.00	130.00	0.00	0.00	0.00	0.00	0.00	0.00
CLAY FOUNDATION ELEV 528 TO 544	3	115.00	115.00	0.00	300.00	0.00	0.00	0.00	0.00	0.00	0.00
SAND FOUNDATION ELEV TO 528	4	120.00	120.00	30.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

CIRCLE FAILURE SURFACE
RESULTS BY HARRIS-500
COMPUTER PROGRAM 741-HS-F424A
TANGENT TO ELEV 544.00
TRIAL ARCS

RADIUS OF CIRCLE	CENTER OF CIRCLE DISTANCE FROM Q	CENTER OF CIRCLE ELEV	F.S. O-SHEAR STR. Ψ= 0.00
38.00	22.00	583.00	2.30
34.00	12.00	578.00	2.87
34.00	32.00	576.00	3.84
24.00	22.00	568.00	2.44
44.00	22.00	588.00	2.31
29.00	22.00	573.00	2.34



NOTES
1- ANALYSES WERE RUN ACCORDING TO EM 1110-2-1902 DATED APRIL 1970
2- THE SIDE EARTH FORCE DIRECTION WAS TAKEN AS THE AVERAGE OF THE EMBANKMENT SLOPES IMMEDIATELY ADJACENT TO THE SLICE INTERFACE
3- PSI-SEISMIC COEFFICIENT USED IN ANALYSES

ANDALUSIA EHP
SLOPE STABILITY ANALYSIS
END OF CONSTRUCTION
STA. 28+00
JULY 1980 (SAZ)

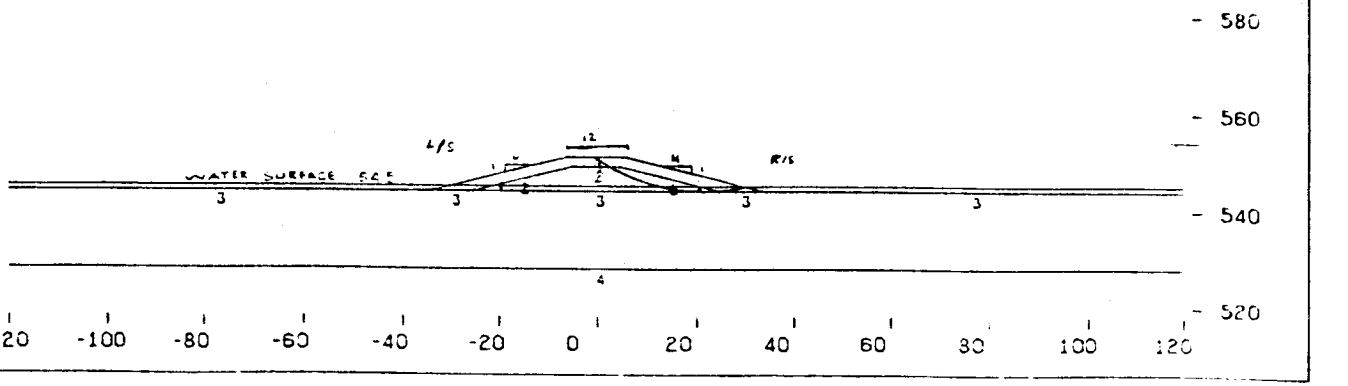
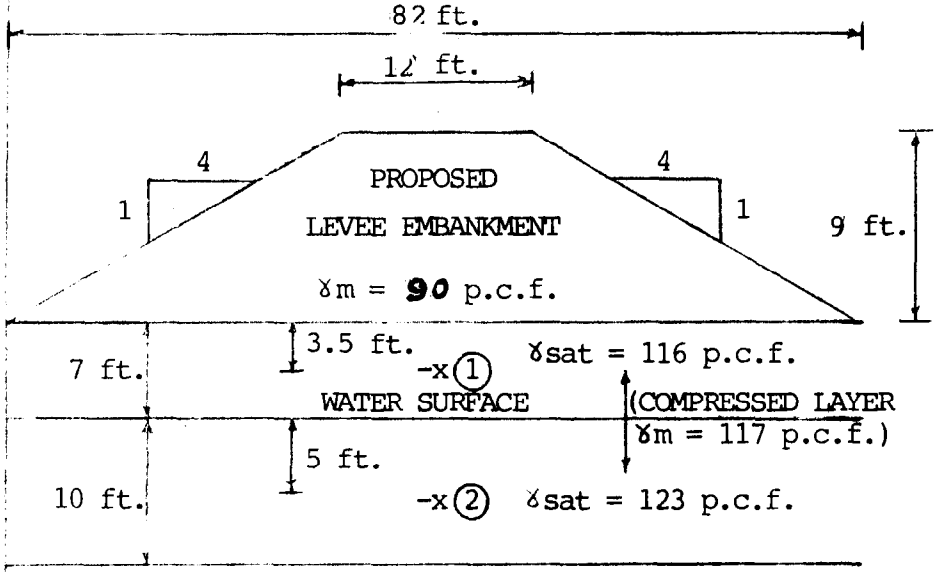


PLATE C-1

Subject		Date
ANDALUSIA EMP ANDALUSIA, ILLINOIS		JUNE 88
Computed by	Checked by	Sheet of
ZS	GC	1 2

ANDALUSIA EMP
ANDALUSIA, ILLINOIS

SETTLEMENT ANALYSIS



Layer 1

Moisture Content = 36%

Ave. LL/(WL) = 71%

Specific Gravity (Gs) = 2.7

e_o = WGs = .36(2.7) = .972

Layer 2

Ave. Moisture Content (Wn) = 28%

Ave. LL/(WL) = 44%

Specific Gravity (Gs) = 2.7

e_o = WGs = (.28)(2.7) = 0.76

P = Stress exerted by the 7 ft. high embankment

P_o = Initial stress at the center of the compressible layer

ΔP_o = Change in stress in compressible layer due to applied loading

C_c = Compression Index

e_o = Initial void Ratio

H = Thickness of compressible layer over which settlement is being calculated

C_c = .30 (e_o-.27): Ref. Physical & Geotechnicial Properties of Soils by Joseph E. Bowles.

C_c = .210 (layer 1), C_c = .147 (layer 2)

C_c = .009 (LL-10): Ref. Soil Mechanics in Engineering Practice by Terzaghid & Peck

C_c = .549 (layer 1), C_c = .306 (layer 2)

Use C_c = .37(e_o + .003WL + .0004Wn - .34), C_c = .318 (layer 1), C_c = .208 (layer 2) Ref. fnd. Analysis & design by Joseph E. Bowles. It is recommended by Joseph E. Bowles which has a reported 86% reliability.

Subject		Date
ANDALUSIA EMP - ANDALUSIA, ILLINOIS		JUNE 88
Computed by SZ	Checked by GC	Sheet 2 of 2

P_o:

@ mid depth of layer No. 1 = 3.5(116-62.4) = 188 p.s.f.

@ mid depth of layer No. 2 = 7(116-62.4) + 5(123 - 62.4) = 678 p.s.f.

ΔP_o @ layer 1 Boussinesq coefficient * h * m.
(.982)*(9)*(90) = 795 p.s.f.

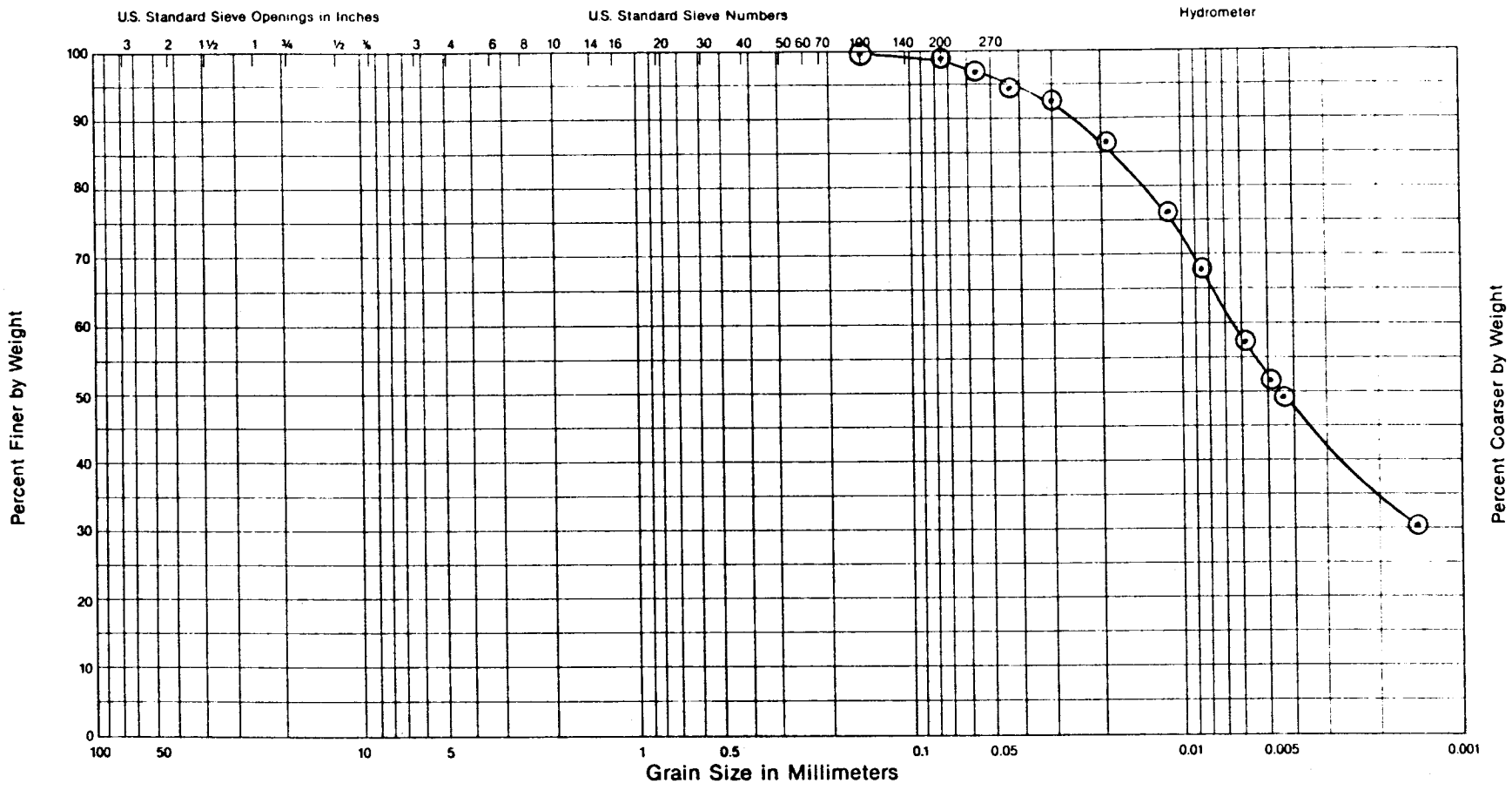
@ layer 2 Boussinesq coefficient * h * m.
(.861)*(9)*(90) = 697 p.s.f.

$$S = \frac{C_c}{1 + e_o} H \log_{10} \frac{P_o + \Delta P_o}{P_o}$$

Depth (ft.)		C_c	P_o (p.s.f.)	ΔP_o (p.s.f.)	H (ft.)	S (ft.)
0						
7	3.5	.318	188	795	7	.81
17	10	.208	678	697	10	.36

TOTAL SETTLEMENT = 1.2 ft. 14 inches

PLATE C-3



GRAVEL		SAND			SILT or CLAY
Coarse	Fine	Coarse	Medium	Fine	

GRAIN SIZE DISTRIBUTION CURVE

Boring No.	Sample No.	Depth or Elev.	Description	Unified Symbol	Natural WC	LL	PL	PI
A-4	1	2.5' to 3.5'						

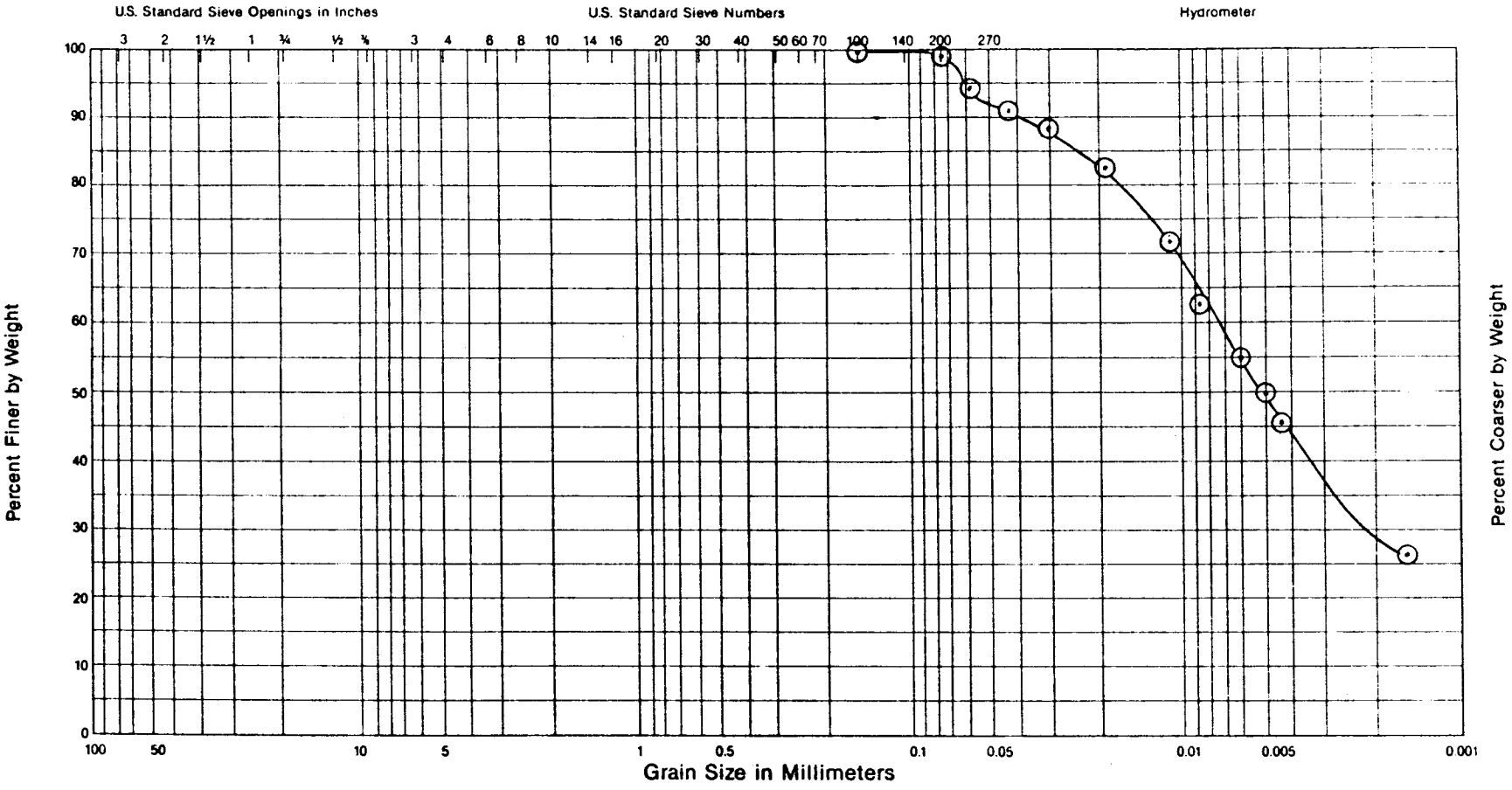
Project Andalusia Refuge Emp

Call #7002 (18Mar87) Job No. 07861088D Date 4-10-87

Terracon

PLATE C-4

Form 124



GRAVEL		SAND			SILT or CLAY
Coarse	Fine	Coarse	Medium	Fine	

GRAIN SIZE DISTRIBUTION CURVE

Boring No.	Sample No.	Depth or Elev.	Description	Unified Symbol	Natural WC	LL	PL	PI
A-5	1	3'		CH		61	27	34

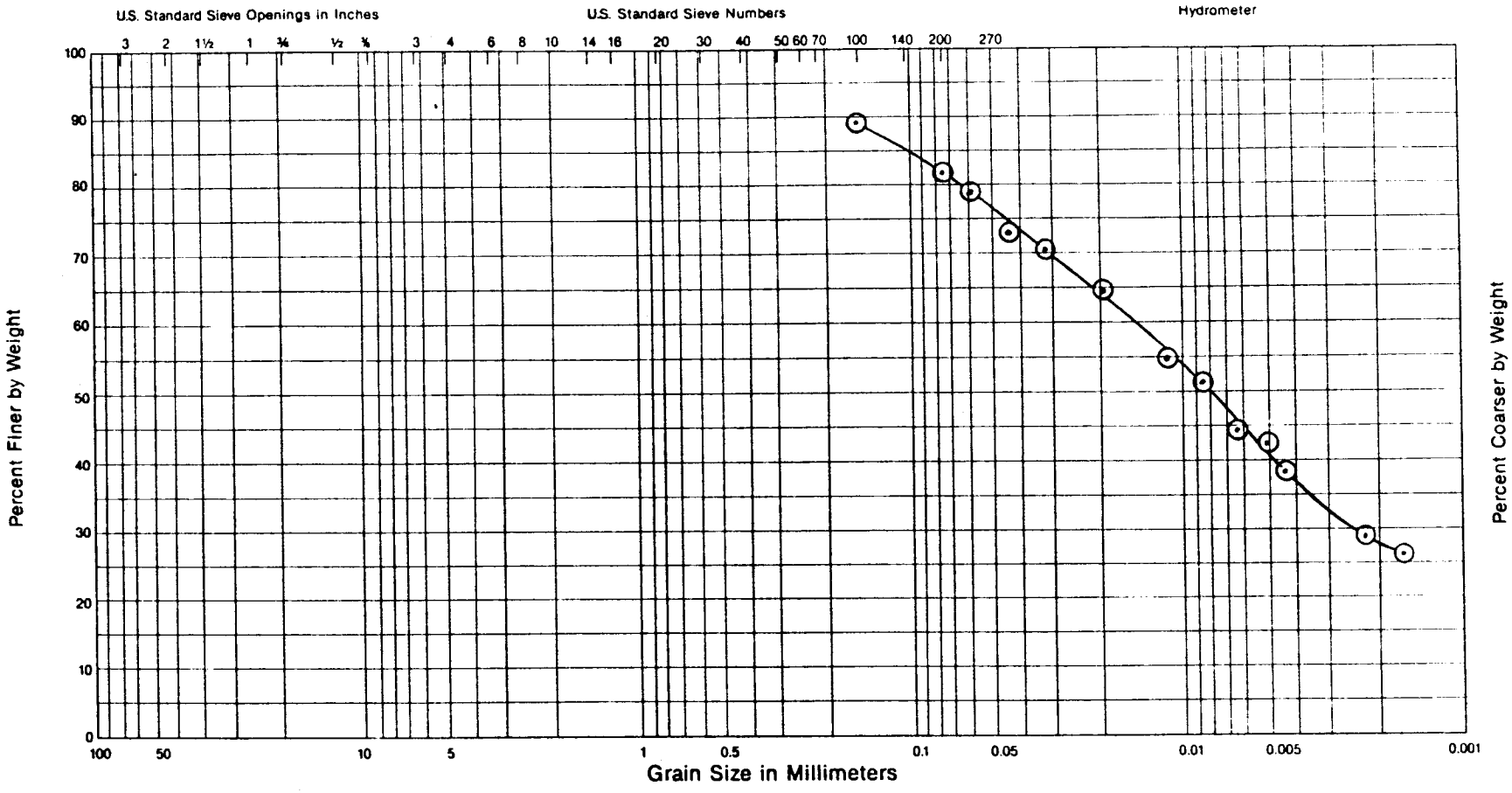
Project Andalusia Refuge Emp

Call #7002 (18Mar87) Job No. 07861088D Date 4-10-87

Terracon

PLATE C-5

Form 124



GRAVEL		SAND			SILT or CLAY
Coarse	Fine	Coarse	Medium	Fine	

GRAIN SIZE DISTRIBUTION CURVE

Boring No.	Sample No.	Depth or Elev.	Description	Unified Symbol	Natural WC	LL	PL	PI
A-5	3	7'	Specific Gravity = 2.654	CL		46	16	30

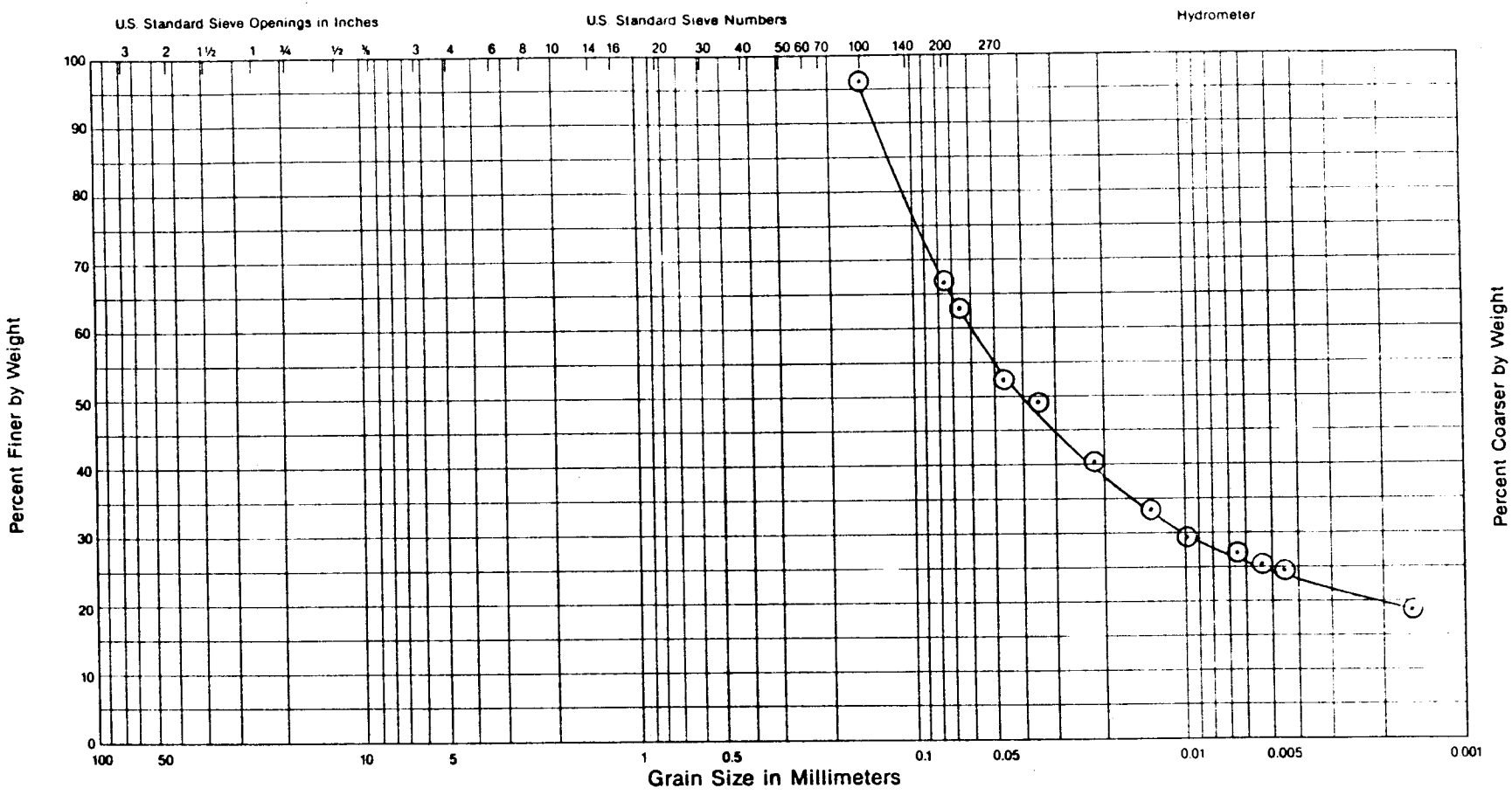
Project Andalusia Refuge Emp

Call #7002 (18Mar87) Job No. 07861088D Date 4-13-87

Terracon

PLATE C-6

Form 124



GRAVEL		SAND			SILT or CLAY
Coarse	Fine	Coarse	Medium	Fine	

GRAIN SIZE DISTRIBUTION CURVE

Boring No.	Sample No.	Depth or Elev.	Description	Unified Symbol	Natural WC	LL	PL	PI
A-2	2	4'		CL		34	17	17

Project Andalusia Refuge Emp

Call #7002 (18Mar87) Job No. 07861088D Date 4-10-87

Terracon

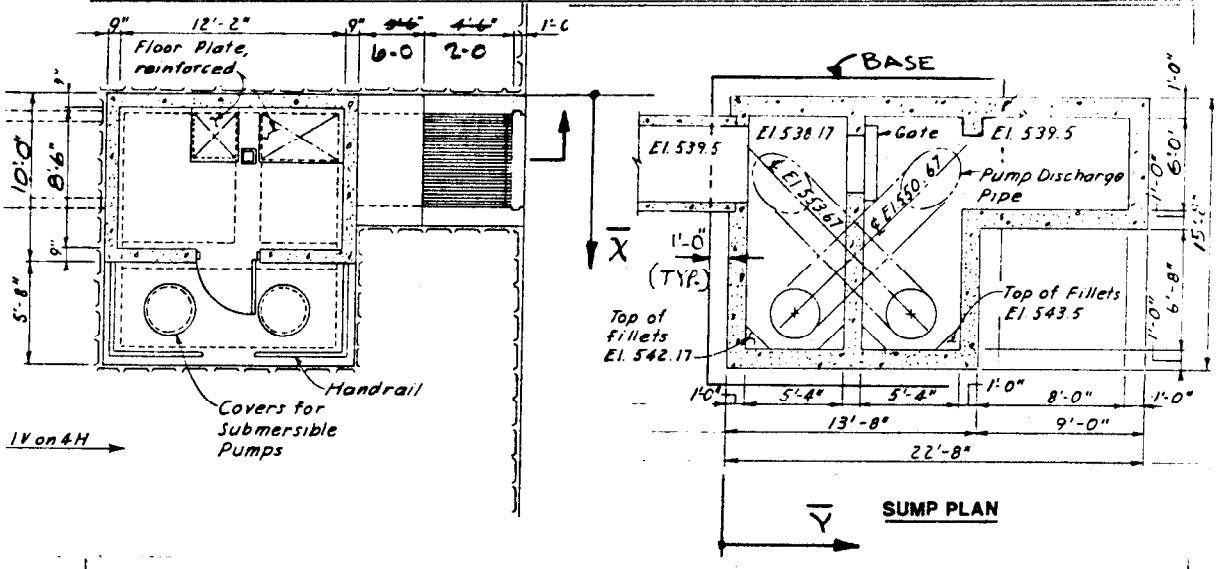
PLATE C-7

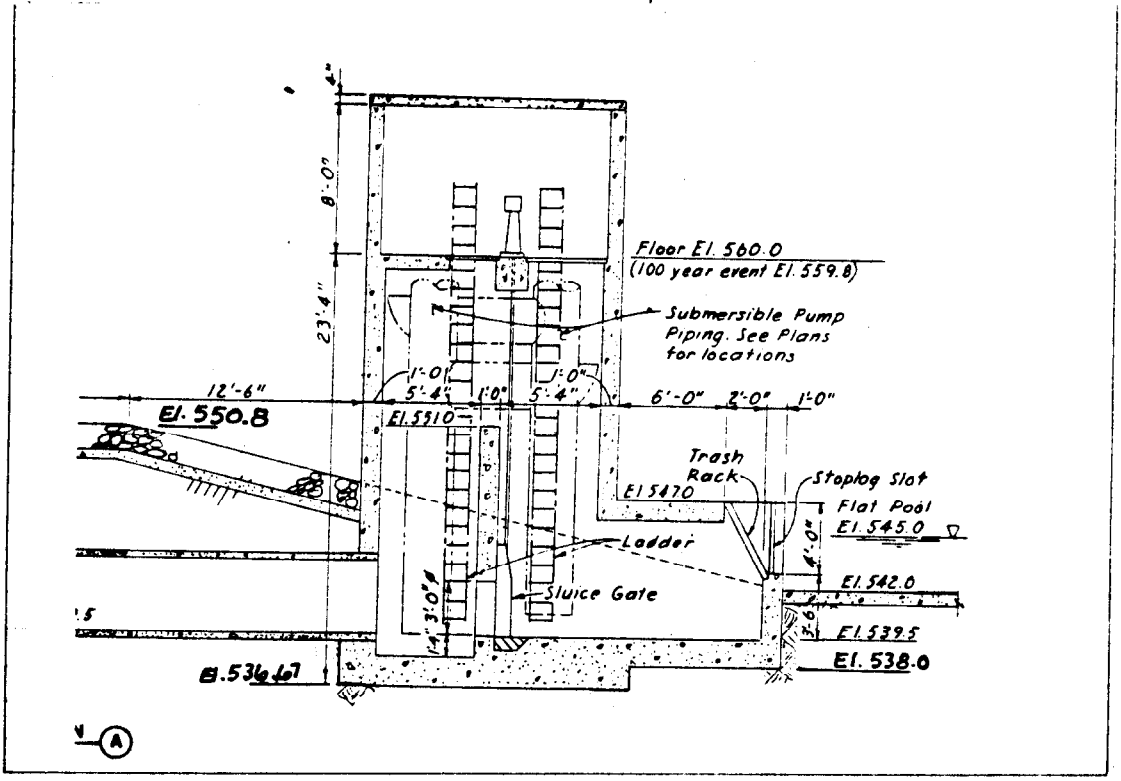
Form 124

STRUCTURAL DESIGN

APPENDIX D

Subject		Date
ANDALUSIA SLOUGH - PUMP STATION		16 MAY 86
Computed by KEW	Checked by CHJ	Sheet 1S-A





NCR Form 1 Aug 80 381b

Subject	ANDALUSIA SLOUGH - PUMP STATION	Date 15 FEB 88
Computed by KEW	Checked by chJ	Sheet PS 1 of

FORCES ON PUMP STATION

REFERENCES

① TM 5-809-1/AFM 88-3, CHAP-1, "LOAD ASSUMPTIONS FOR BUILDINGS", CE MAR. 87

② "STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGES" AASHTO, 1983

③ EM 1110-2-2607, "NAVIGATION DAM MASONRY" 1 JULY '58

WIND FORCES REF. ①, CHAPTER 5

$V = 80$ mph ASSUME EXPOSURE C

$q_z = 0.00256\, K_z (IV)^2$ WHERE K_z = VELOCITY PRESSURE COEF. (Table 5-5)

HEIGTH OF PUMP STATION IS
≃ 20 FT ABOVE THE LEVEE
≃ 9 FT ABOVE 100 YR FLOOD.

I = IMPORTANCE FACTOR (Table 5-4)

= 1.00

z	K_z	q_z
0-15	0.80	13.11 psf
20	0.87	14.25 psf

$p = q\, G_h\, C_p$ WHERE G_h = GUST RESPONSE FACTOR (Table 5-6)

Subject	ANDALUSIA SLOUGH - PUMP STATION	Date
Computed by KEW	Checked by chJ	Sheet PS 2 of

FORCES ON PUMP STATION

z	G_h
0-15	1.32
20	1.20

C_p = EXTERNAL PRESSURE COEFF. (Figure 5-6)

z	WINDWARD WALL $C_p = 0.8$	LEEWARD WALL $C_p = -0.5$
0-15	$q_{WALL} = 13.85$ psf	$q_{WALL} = -8.66$ psf
20	$q_{WALL} = 14.71$ psf	$q_{WALL} = -9.19$ psf

q_{WALLS} =

z	TOTAL
0-15	22.51 psf
20	23.90 psf

$q_{ROOF} = 14.25\ (1.20)\ (-0.7) = 12.87$ psf

RIVER FLOW FORCES REF. (2), SEC. 3.18.1

$q = KV^2$

$= 1.375\ (7.0)^2$

$= 68$ psf

V = FLOW OF RIVER = 7 ft/sec. (FOLEY-HW)

K = CONSTANT = 1.375 FOR FLAT SURFACE

Subject		Date
ANDALUSIA SLOUGH - PUMP STATION		27 MAY 8
Computed by KEW	Checked by chJ	Sheet PS 3 of

WEIGHT OF PUMP TUBE

ASSUME 1/4" PLATE FOR TUBES, WT. = 10.2 #/FT²

TUBE I.D. = 32" ; PERIMETER = $\pi(D) = \pi\left(\frac{32}{12}\right)$

$= 8.443$ FT

VERT. TUBE LENGTH

INTAKE PUMP = 562.0 - 539.5 - 1.33 = 21.17 FT

OUTLET PUMP = 562.0 - 539.5 = 22.50 FT

VERT. TUBE WEIGHT

INTAKE PUMP = 10.2 (8.443)(21.17) = 1,823 #

OUTLET PUMP = 10.2 (8.443)(22.50) = 1,938 #

HORIZ. TUBE LENGTH

INTAKE PUMP = 10.2 (8.443)(11.25) = 969 #

OUTLET PUMP = " " " = 969 #

WEIGHT OF PUMPS = 2,870 # EACH (MANUF. DATA)

WEIGHT OF H_2O IN VERT. TUBES

INTAKE PUMP = $\pi\frac{(16)^2}{144}(21.17 - 1.04)(62.4) = 7,016$ #

OUTLET PUMP = $\pi\frac{(16)^2}{144}(22.50 - 1.04)(62.4) = 7,479$ #

Subject ANDALUSIA SLOUGH – PUMP STATION		Date 27 MAY 82
Computed by KEW	Checked by chJ	Sheet PS4 of

WEIGHT OF H_2O IN HORIZ. TUBES

$$\text{INTAKE PUMP} = \frac{\pi (16)^2}{144} (11.25)(62.4) = 3,921\ \#$$

$$\text{OUTLET PUMP} = 3,921\ \#$$

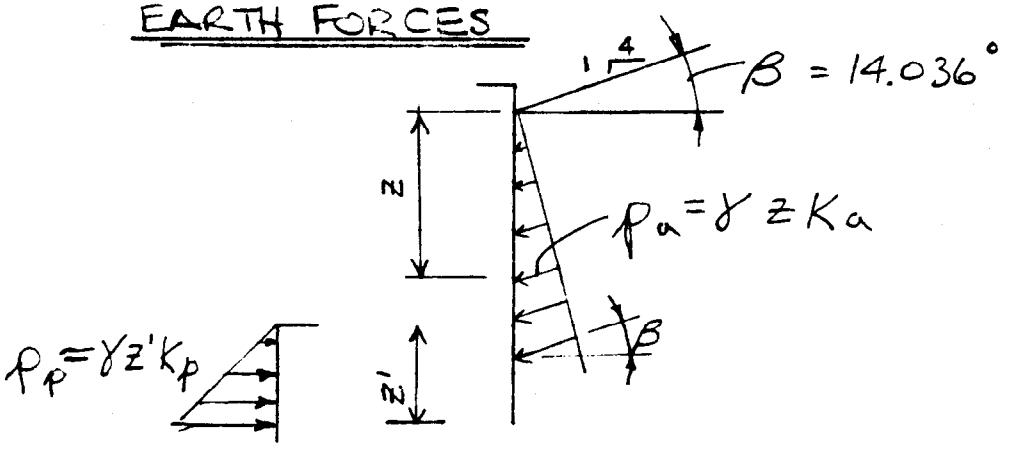
Subject ANDALUSIA SLOUGH - PUMP STATION		Date 24 JUNE 88
Computed by KEV	Checked by chJ	Sheet PS5 of

FORCES ON PUMP STATION

EARTH FORCES

BACKFILL MAT'L

$\gamma_{DAMP} = 115$ pcf
$c = 0$
$\phi = 32°$



$$K_a = \cos\beta \left[\frac{\cos\beta - \sqrt{\cos^2\beta - \cos^2\phi}}{\cos\beta + \sqrt{\cos^2\beta - \cos^2\phi}} \right]$$

$$K_a = 0.97014 \left[\frac{0.97014 - \sqrt{(0.97014)^2 - (0.84805)^2}}{0.97014 + \sqrt{(0.97014)^2 - (0.84805)^2}} \right]$$

$$= 0.97014 \frac{(0.97014 - 0.47115)}{(0.97014 + 0.47115)} = 0.33587$$

$$K_{a,H} = 0.97014\ (0.33587) = 0.32584$$

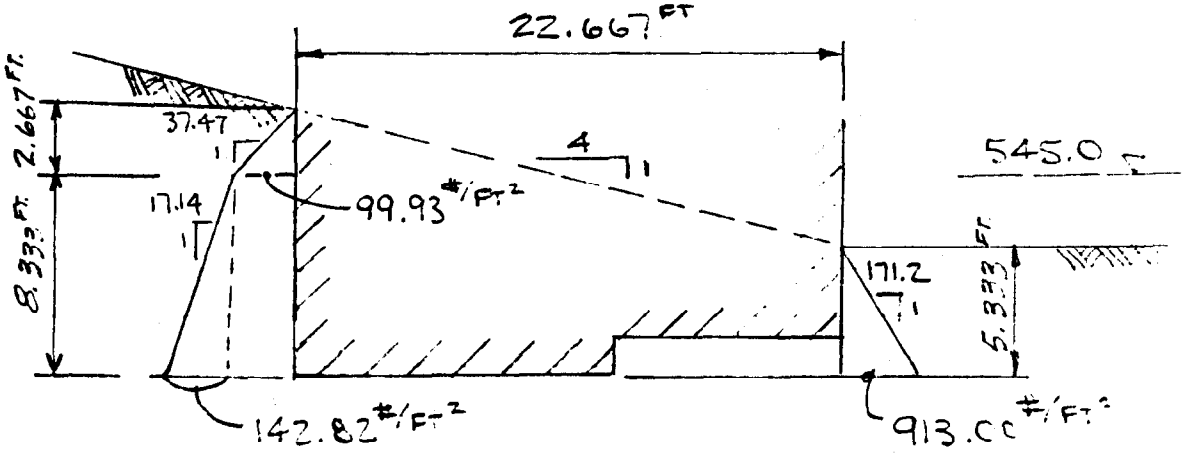
$$K_p = \tan^2\left(45 + \frac{\phi}{2}\right)$$

$$= \tan^2\left(45 + \frac{32}{2}\right) = 3.25947$$

Subject ANDALUSIA SLOUGH - PUMP STATION		Date JUNE 84
Computed by KEW	Checked by CHJ	Sheet PS 6 of

FORCES ON PUMP STATION

EARTH FORCES



ICE FORCES

BECAUSE THE REFUGE IS ABOVE THE PUMP STATION AND FLAT POOL AND HIGH WATER WITHIN THE REFUGE IS BELOW THE TOP OF THE LEVEE, ICE FORCES WILL NOT ACT ON THE PUMP STATION.

FLOATING OBJECTS

THE PUMP STATION IS IN A PROTECTED AREA, OUT OF THE MAIN FLOW OF THE RIVER. IT WILL NOT BE SUBJECT TO LARGE FLOATING OBJECTS.

Subject		Date
ANDALUSIA SLOUGH - PUMP STATION		18 MAY 88
Computed by KEW	Checked by chJ	Sheet PS7 of

REVISED 12 OCT. 88

STABILITY ($\bar{Y}$)

UNIT		FORCE	ARM	MOMENT
ROOF	0.33(150)(10.00)(13.67)	6,835	6.833	46,704
WALLS	0.75(150)(8.00)(13.67)(2)	24,606	6.833	168,133
	-0.75(150)(7.17)(3.33)	- 2,686	6.833	- 18,353
	0.75(150)(8.00)(8.50)	7,650	0.375	2,869
	0.75(150)(8.00)(8.50)	7,650	13.292	101,684
FLOOR	0.50(150)(13.67)(11.67)	11,965	6.833	81,755
	-0.50(150)(2.50)(2.50)	- 469	5.917	- 2,775
	-0.50(150)π(1.333)²	- 419	3.667	- 1,536
	-0.50(150)π(1.333)²	- 419	10.000	- 4,190
	-0.50(150)(2.5)(4.17)	- 782	10.583	- 8,276
BMS	0.50(150)(8.00)(0.83)	498	7.833	3,901
(BELOW SLAB)	1.33(150)(11.67)(1.25)	2,910	6.833	19,884
WALLS	1.00(150)(20.50)(15.67)	48,185	13.167	634,451
	-1.00(150)(7.00)(5.00)	- 5,250	13.167	- 69,127
	1.00(150)(20.50)(15.67)	48,185	0.500	24,093
	-1.00(150)π(2.00)²	- 1,885	0.500	- 942
	1.00(150)(20.50)(11.67)(2)	71,770	6.833	490,404
	1.00(150)(11.50)(13.67)	23,581	6.833	161,129
	-1.00(150)(3.00)(3.00)	- 1,350	6.833	- 9,225
BASE	2.83(150)(17.67)(15.67)	117,539	6.833	803,144
	-1.33(150)(13.67)(5.33)	-14,536	3.667	- 53,304
		343,578 #		2,370,423 FT-#

$\bar{Y}$ = 6.899 FT.

NCR Form 1 Aug 80 381b

Subject		Date
ANDALUSIA SLOUGH - PUMP STATION		19 MAY 88
Computed by KEW	Checked by chJ	Sheet PS 8 of

REVISED 19 OCT. 88

STABILITY ($\bar{Y}$)

UNIT	FORCE	ARM	MOMENT
WIND 24(10.00)(8.33)	2,000	27.495	54,990
24(15.67)(9.20)	3,460	18.733	64,816
RIVER FLOW 68(15.67)(9.20)	9,803	18.733	183,640
EARTH LOADS (NORMAL)(SHT. PS6)			
ACTIVE			
$37.47(2.667)(\frac{2.667}{2})(15.67)$	2,088	9.222	19,256
37.47(2.667)(8.333)(15.67)	13,049	4.167	54,375
$17.14(8.333)(\frac{8.333}{2})(15.67)$	9,325	2.777	25,896
PASSIVE			
$171.2(5.333)(\frac{5.333}{2})(15.67)$	-38,172 *	—	
*PASSIVE FORCE IS GREATER THAN ACTIVE FORCES INCLUDING WIND AND EARTH, ∴ USE ΣACTIVE	+29,922	1.777	- 53,171
EARTH LOADS (100YR.)			
ACTIVE			
$17.14(11.00)(\frac{11.00}{2})(15.67)$	16,249	3.667	59,585
PASSIVE (SEE ABOVE)	-38,172 **		
**PASSIVE FORCE IS GREATER THAN ACTIVE FORCES INCLUDING WIND, RIVER FLOW & EARTH, ∴ USE ΣACTIVE	-28,052	1.777	- 49,848

Subject	ANDALUSIA SLOUGH - PUMP STATION	Date	19 MAY 88
Computed by	KEW	Checked by	chJ
Sheet	PS9 of		

REVISED 18 OCT. 88

STABILITY ($\bar{Y}$)

UNIT	FORCE	ARM	MOMENT
PUMPS & PIPING			
2,870 + 1,938 (1.10)	5,002	3.667	18,342
2,870 + 1,823 (1.10)	4,875	10.000	48,750
969 (1.10)	1,066	5.500	5,863
969 (1.10)	1,066	8.167	8,706
LIVE LOAD 100 (8.5)(12.167)	10,342	6.833	70,667
SNOW LOAD 20 (15.667)(13.667)	4,282	6.833	29,259
INLET 0.50 (150)(6.00)(6.00)	2,700	16.667	45,001
1.00 (150)(7.50)(9.00) 2	20,250	18.167	367,882
1.00 (150)(6.00)(3.50)	3,150	22.167	69,826
1.50 (150)(8.00)(8.00)	14,400	18.667	268,805
	40,500*	18.556	751,514 Ft-#
WATER (NORMAL)			
(542.00 - 538.17)(62.4)(5.33)(13.67)	17,413	3.667	63,853
(545.00 - 539.50)(62.4)(5.33)(13.67)	25,006	10.000	250,060
(545.00 - 539.50)(62.4)(6.00)(9.00)	18,533	17.167	318,156
(545.00 - 543.00)(62.4)(6.00)(1.00)	749	22.167	16,603
(545.00 - 539.50)(62.4)(15.67)(1.00) 2	10,756	6.833	73,496
(545.00 - 539.50)(62.4)(7.67)(1.00)	2,632	14.167	37,288
(545.00 - 539.5)(62.4)(15.67)(1.00)	5,378	-0.500	- 2,689
$-\pi(2.333)^2$ (62.4)(1.00)	- 1,067	-0.500	534
	79,400#		757,301

Subject	ANDALUSIA SLOUGH - PUMP STATION	Date	19 MAY 82
Computed by	KEW	Checked by	chJ
Sheet	PS1C of		

REVISED ECT. 8'

STABILITY (Ȳ)

UNIT	FORCE	ARM	MOMENT
EARTH ON BASE PROJ. (NORMAL)			
(115 - 62.4)(5.5)(15.67)(1.00)2	9,067	6.833	61,955
- (115 - 62.4)(1.0)(4.000/2)(1.00)2	- 210	13.333	- 2,800
115 (547.917 - 545.0)(11.67/2)(1.00)2	3,915	2.889	11,312
(115 - 62.4)(4.625)(7.67)(1.00)	1,866	14.167	26,436
(115 - 62.4)(5.5)(15.67)(1.00)	4,533	-0.500	- 2,267
115 (2.792)(15.67)(1.00)	5,031	-0.500	- 2,516
-(115 - 62.4)π(2.333)² (1.00)	- 899	-0.500	450
	23,305 #	3.972	92,569 F.=
UPLIFT (NORMAL)			
-(545.0 - 536.67)(62.4)(17.67)(15.67)	-143,925	6.833	- 983,440
-(545.0 - 536.00)(62.4)(8.00)(8.00)	- 27,955	18.667	- 521,840
	- 171,880 #	8.758	- 1,505,280 F.=
WATER (100 YR.)			
(559.30 - 538.17)(62.4)(5.33)(13.67)	96,066	3.667	352,281
(559.30 - 539.50)(62.4)(5.33)(13.67)	90,021	10.000	900,210
(559.30 - 551.00)(62.4)(1.00)(13.67)	7,080	6.833	48,378
(559.80 - 530.50)(62.4)(6.00)(8.00)	60,803	17.667	1,074,207
(546.50 - 539.50)(62.4)(1.00)(5.00)	2,184	13.167	28,757
- 0.50(62.4)(6.00)(6.00)	- 1,123	16.667	- 18,717
(559.80 - 543.00)(62.4)(1.00)(6.00)	6,290	22.167	139,430
(559.80 - 547.00)(62.4)(1.00)(9.00)2	14,377	18.167	261,187
(559.80 - 539.50)(62.4)(15.67)(1.00)2	39,699	6.833	271,263

Subject		Date
MALAYSIA SLOVAK - PUMP STATION		18 OCT. 88
Computed by KEN	Checked by chd	Sheet PS10a

STABILITY (T)

UNIT	FORCE	ARM	MOMENT
WATER (100 YR) (CONT.)			
(559.80 - 539.5)(62.4)(7.67)(1.00)	9,716	14.167	137,647
(559.8 - 539.5)(62.4)(15.67)(1.00)	19,850	- 0.500	- 9,925
- π (2.333)² (62.4)(1.00)	- 1,067	- 0.500	534
	343,898#		F.= 3,185,252
EARTH ON BASE PROJ. (100 YR.)			
52.6 (5.5)(15.67)(1.00) 2	9,067	6.833	61,955
- 52.6 (1.0)(4.00)(1.00) 2	- 210	13.333	- 2,800
52.6 (2.917)(11.67)(1.00) 2	1,791	2.889	5,174
52.6 (4.625)(7.67)(1.00)	1,866	14.167	26,436
52.6 (8.292)(15.67)(1.00)	6,835	-0.500	- 3,417
- 52.6 π (2.333)² (1.00)	- 899	-0.500	450
	18,450#		F.= 87,798
UP LIFT (100 YR.)			
-(559.8 - 536.67)(62.4)(17.67)(15.67)	-399,637	6.833	-2,730,720
-(559.8 - 538.00)(62.4)(8.00)(8.00)	- 87,060	18.667	- 1,625,158
	-486,697#		F.= -4,355,878

Subject		Date
ANDALUSIA SLOUGH – PUMP STATION		18 MAY 88
Computed by KEW	Checked by CHJ	Sheet PS11 of

REVISED 18 OCT. 88

STABILITY ($\bar{x}$)

UNIT	FORCE	ARM	MOMENT
ROOF 0.33 (150)(10.00)(13.67)	6,835	5.000	34,175
WALLS 0.75 (150)(8.00)(13.67)	12,303	0.375	4,614
0.75(150)(8.00)(13.67)	12,303	9.625	118,416
−0.75(150)(7.17)(3.33)	−2,686	9.625	−25,853
0.75(150)(8.00)(8.50)(2)	15,300	5.000	76,500
FLOOR 0.50 (150)(13.67)(11.67)	11,965	7.833	93,722
− 0.50 (150)(2.50)(2.50)	− 469	2.250	− 1,055
− 0.50 (150) π (1.333)² (2)	− 838	12.667	− 10,615
− 0.50 (150)(2.5)(4.17)	− 782	2.250	− 1,760
BMS. 0.50(150)(8.00)(0.83)	498	5.000	2,490
(BELOW SLAB) 1.33 (150)(11.67)(1.25)	2,910	9.625	28,009
WALLS 1.00 (150)(20.50)(15.67)(2)	96,370	7.833	754,866
− 1.00 (150)(7.00)(5.00)	− 5,250	4.500	− 23,625
− 1.00 (150) π (2.00)²	− 1,885	4.500	− 8,483
1.00(150)(20.50)(11.67)	35,885	0.500	17,943
1.00 (150)(20.50)(11.67)	35,885	15.167	544,268
1.00 (150)(11.50)(13.67)	23,581	7.833	184,710
−1.00 (150)(3.00)(3.00)	− 1,350	4.500	− 6,075
BASE 2.83 (150) (17.67)(15.67)	117,539	7.833	920,683
−1.33 (150) (13.67)(5.33)	−14,536	7.833	− 113,860
	343,578#		2,589,07[illegible]#

$\bar{x}$ = 7.536 FT.

Subject		Date
ANDALUSIA SLOUGH - PUMP STATION		19 MAY 88
Computed by KEW	Checked by chJ	Sheet PS12 of

REVISED 18 OCT. 88

STABILITY ($\bar{x}$)

UNIT		FORCE	ARM	MOMENT
WIND	24 (13.67)(20.66)	6,778	21.337	144,622
	24 (13.67)(3.417) ÷ 2	561	9.867	5,535
	24 (9.00)(2.75)	594	8.958	5,321
	24 (9.00)(2.25) ÷ 2	243	6.833	1,660
		8,176#		157,138 FT-#
RIVER FLOW - NONE		—	—	—
EARTH - EQUAL ON OPP. SIDES		—	—	—
PUMPS & PIPING				
	2,870 + 1938 (1.10)	5,002	12.667	63,360
	2,870 + 1823 (1.10)	4,875	12.667	61,752
	969 (1.10)(2)	2,132	8.667	18,478
LIVE LOAD	100 (8.5)(12.167)	10,342	5.000	51,710
SNOW LOAD	20 (15.667)(13.667)	4,282	7.833	33,541
INLET	0.50 (150)(6.0)(6.0)	2,700	4.000	10,800
	1.00 (150)(7.5)(9.00)	10,125	0.500	5,063
	1.00 (150)(7.5)(9.00)	10,125	7.500	75,937
	1.00 (150)(6.00)(3.50)	3,150	4.000	12,600
	1.50 (150)(8.00)(8.00)	14,400	4.000	57,600
		40,500#	4.000	162,000 FT-#

* AVG. EXPOSED HT.

Subject ANDALUSIA SLOUGH - PUMP STATION		Date 12-1-88
Computed by KEW	Checked by CHK	Sheet 1 of 1

REVISED 12-7-88

STABILITY ($\bar{X}$)

UNIT	FORCE	ARM	MOMENT
WATER (NORMAL)			
(542.00 - 538.17)(62.4)(5.33)(13.67)	17,413	7.833	136,396
(545.00 - 539.50)(62.4)(5.33)(13.67)	25,006	7.833	195,872
(545.00 - 539.50)(62.4)(6.00)(9.00)	18,533	4.000	74,132
(545.00 - 543.00)(62.4)(6.00)(1.00)	749	4.000	2,996
(545.00 - 539.50)(62.4)(15.67)(1.00)	5,378	- 0.500	- 2,689
(545.00 - 539.50)(62.4)(15.67)(1.00)	5,378	16.167	86,946
(545.00 - 539.50)(62.4)(7.67)(1.00)	2,632	11.833	31,144
(545.00 - 539.50)(62.4)(15.67)(1.00)	5,378	7.833	42,126
$-\pi(2.333)^2(62.4)(1.00)$	- 1,067	4.500	- 4,802
	79,400#		562,121
EARTH ON BASE PROJ. (NORMAL)			
(115 - 62.4)(5.5)(15.67)(1.00)2	9,067	7.833	71,022
$-(115 - 62.4)(1.0)(\frac{4.00}{2})(1.00)2$	- 210	7.833	- 1,645
$115(547.917 - 545.0)(\frac{11.67}{2})(1.00)2$	3,915	7.833	30,666
(115 - 62.4)(4.625)(7.67)(1.00)	1,866	11.833	22,080
(115 - 62.4)(5.5)(15.67)(1.00)	4,533	7.833	35,507
115(2.792)(15.67)(1.00)	5,031	7.833	39,408
$-(115 - 62.4)\pi(2.333)^2(1.00)$	- 899	4.500	- 4,046
	23,303#		192,992
UPLIFT (NORMAL)			
-(545.0 - 536.67)(62.4)(17.67)(15.67)	- 143,925	7.833	-1,127,365
-(545.0 - 538.00)(62.4)(8.00)(8.00)	- 27,955	4.000	- 111,820
	-171,880#		- 1,239,185

NCR Form 381b
1 Aug 80

Subject		Date
ANDALUSIA SLOUGH - PUMP STATION		18 OCT. 82
Computed by KEW	Checked by chd	Sheet PS.3a of

STABILITY ($\bar{X}$)

UNIT	FORCE	ARM	MOMENT
WATER (100 YR.)			
(559.30 - 538.17)(62.4)(5.33)(13.67)	96,068	7.833	752,501
(559.30 - 539.50)(62.4)(5.33)(13.67)	90,021	7.833	705,134
(559.30 - 551.00)(62.4)(1.00)(13.67)	7,080	7.833	55,458
(559.80 - 539.50)(62.4)(6.00)(8.00)	60,803	4.000	243,212
(546.50 - 539.50)(62.4)(1.00)(5.00)	2,184	4.500	9,828
- 0.50 (62.4)(6.00)(6.00)	- 1,123	4.000	- 4,492
(559.80 - 543.00)(62.4)(1.00)(6.00)	6,290	4.000	25,160
(559.80 - 547.00)(62.4)(1.00)(9.00)2	14,377	4.000	57,508
(559.80 - 539.50)(62.4)(15.67)(1.00)2	39,699	7.833	310,962
(559.80 - 539.50)(62.4)(7.67)(1.00)	9,716	11.833	114,967
(559.80 - 539.50)(62.4)(15.67)(1.00)	19,850	7.833	155,467
- π (2.333)^2 (62.4)(1.00)	- 1,067	4.500	- 4,802
	343,898#		2,420,923 Ft-#
EARTH ON BASE PROJ. (100 YR.)			
52.6 (5.5)(15.67)(1.00) 2	9,067	7.833	71,022
- 52.6 (1.0)$\left(\frac{4.00}{2}\right)$(1.00) 2	- 210	7.833	- 1,645
52.6 (2.917)$\left(\frac{11.67}{2}\right)$(1.00) 2	1,791	7.833	14,029
52.6 (4.625)(7.67)(1.00)	1,866	11.833	22,080
52.6 (8.292)(15.67)(1.00)	6,835	7.833	53,539
- 52.6 π (2.333)^2 (1.00)	- 899	4.500	- 4,046
	18,450#		154,947 Ft-#
UPLIFT (100 YR.)			
-(559.8 - 536.67)(62.4)(17.67)(15.67)	- 399,637	7.833	-3,130,357
-(559.8 - 538.00)(62.4)(8.00)(8.00)	- 87,060	4.000	- 348,240
	-486,697#		-3,478,597 Ft-#

NCR Form 1 Aug 80 381b

Subject ANDALUSIA SLOUGH - PUMP STATION		Date 20 JUNE 88
Computed by KEW	Checked by chJ	Sheet PS14 of

REVISED 18 OCT. 88

STABILITY ($\bar{Y}$)

LOAD CASE I NORMAL CONDITIONS

UNIT		FORCE	ARM	MOMENT
		#		FT-#
DEAD LOAD OF STRUCTURE	↓	343,578	6.899	2,370,423
WIND	→	2,000	27.495	54,990
		3,460	18,733	64,816
EARTH - ACTIVE	→	2,088	9.222	19,256
		13,049	4.167	54,375
		9,325	2.777	25,896
- PASSIVE	←	- 29,922	1.777	- 53,171
PUMPS & PIPING	↓	12,009	6.800	81,661
LIVE LOAD	↓	10,342	6.833	70,667
SNOW LOAD	↓	4,282	6.833	29,259
INLET	↓	40,500	18.556	751,518
WATER	↓	79,400	9.538	757,301
EARTH ON BASE PROJ.	↓	23,303	3.972	92,568
UPLIFT	↑	-171,880	8.758	-1,505,280
		# 341,534	8.240	FT-# 2,814,275

$$e_Y = 8.240 - \frac{13.667}{2} = 1.407 \text{ FT} < \frac{13.667}{6} = 2.278 \text{ FT}$$

Subject	ANDALUSIA SLOUGH - PUMP STATION	Date 30 JUNE 88
Computed by KEW	Checked by chd	Sheet PS15 of

REVISED 19 OCT. 88

STABILITY ($\bar{X}$)

LOAD CASE I NORMAL CONDITIONS

UNIT		FORCE	ARM	MOMENT
		#		FT-#
DEAD LOAD OF STRUCTURE	↓	343,578	7.536	2,589,070
WIND (NOT IN CONJ. W/ $\bar{Y}$ WIND)	→	—	—	—
PUMPS & PIPING	↓	12,009	11.957	143,590
LIVE LOAD	↓	10,342	5.000	51,710
SNOW LOAD	↓	4,282	7.833	33,541
INLET	↓	40,500	4.000	162,000
WATER	↓	79,400	7.080	562,121
EARTH ON BASE PROJ.	↓	23,303	8.282	192,992
UPLIFT	↑	-171,880	7.210	-1,239,185
		# 341,534	7.308	FT-# 2,495,839

$$e_x = 7.308 - \frac{15.667}{2} = -0.526^{FT} < \frac{15.667}{6} = 2.611^{FT}$$

Subject	ANDALUSIA SLOUGH - PUMP STATION	Date 23 JUNE 88
Computed by KEW	Checked by chJ	Sheet PS16 of

REVISED 19 OCT. 88

STABILITY

LOAD CASE I NORMAL CONDITIONS

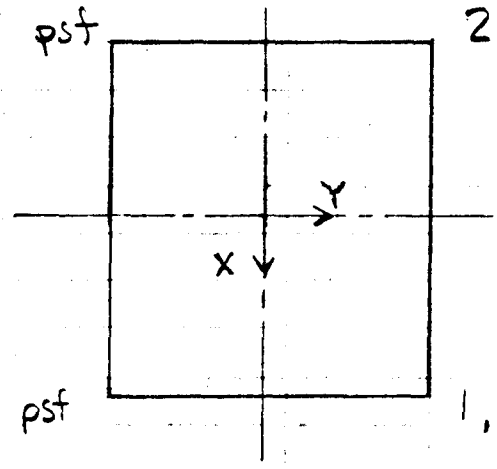
BEARING PRESSURES

$$\frac{P}{A} \pm \frac{Pe_Y}{S_Y} \pm \frac{Pe_X}{S_Y}$$

NOTE: INLET FOOTPRINT WAS NOT USED IN COMPUTING BRG. PRESSURES.

$$\frac{341,534}{15.667(17.667)} \pm \frac{341,534(1.407)6}{17.667(15.667)^2} \pm \frac{341,534(0.526)(6)}{15.667(17.667)^2}$$

$$= 1,233.92 \text{ psf} \pm 664.83 \text{ psf} \mp 220.42 \text{ psf}$$



ALSO SEE SHT. PS 20

Subject		Date
ANDALUSIA SLOUGH - PUMP STATION		20 JUNE 88
Computed by KEW	Checked by chd	Sheet PS 17 of

REVISED 19 OCT. 88

STABILITY ($\bar{Y}$)

LOAD CASE II 100YR. FLOOD CONDITIONS

UNIT		FORCE	ARM	MOMENT
DEAD LOAD OF STRUCTURE	↓	343,578	6.899	2,370,423
WIND	→	2,000	27.495	54.990
RIVER FLOW	→	9,803	18.733	183,640
EARTH - ACTIVE	→	16,249	3.667	59,585
- PASSIVE	←	- 28,052	1.777	- 49,848
PUMPS & PIPING	↓	12,009	6.800	81,661
LIVE LOAD	↓	10,342	6.833	70,667
INLET	↓	40,500	18.556	751,514
WATER	↓	343,898		3,185,252
EARTH ON BASE PROJ	↓	18,450		87,798
UPLIFT	↑	- 486,697		-4,355,878
		282,080 #	8.649	2,439,804 FT-#

$$e_Y = 8.649 - \frac{13.667}{2} = 1.816 \text{ FT} < \frac{13.667}{6} = 2.278 \text{ FT}$$

Subject		Date
ANDALUSIA SLOUGH - PUMP STATION		20 JUNE 88
Computed by KEW	Checked by CHJ	Sheet PS18 of

REVISED 19 OCT. 88

STABILITY ($\bar{X}$)

LOAD CASE II 100 YR. FLOOD CONDITIONS

UNIT		FORCE	ARM	MOMENT
		#		FT-#
DEAD LOAD OF STRUCTURE	↓	343,578	7.536	2,589,070
WIND (NOT IN CONJ. W/ $\bar{Y}$ WIND)	→	—	—	—
PUMPS & PIPING	↓	12,009	11.957	143,590
LIVE LOAD	↓	10,342		77,710
INLET	↓	40,500		162,000
WATER	↓	343,898		2,420,923
EARTH ON BASE PROJ.	↓	18,450		154,974
UPLIFT	↑	-486,697		-3,478,597
		282,080#	7.245	FT-# 2,043,670

$$e_x = 7.245 - \frac{15.667}{2} = -0.589 \text{ FT} < \frac{15.667}{6} = 2.611 \text{ FT}$$

Subject	ANDALUSIA SLOUGH - PUMP STATION	Date 23 JUNE 88
Computed by KEW	Checked by chJ	Sheet PS 19 of

REVISED 19 OCT. 88

STABILITY

LOAD CASE II 100 YR. FLOOD CONDITIONS

BEARING PRESSURES

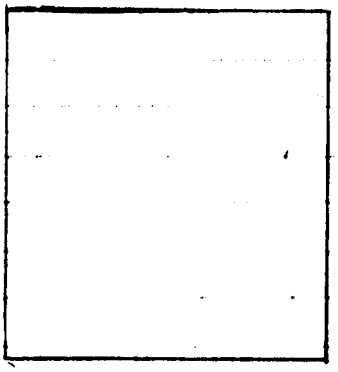
$$\frac{P}{A} \pm \frac{P e_y}{S_y} \pm \frac{P e_x}{S_x}$$

NOTE: INLET FOOTPRINT WAS NOT USED IN COMPUTING BRG. PRESSURES.

$$= \frac{282{,}080}{(15.667)(17.667)} \pm \frac{282{,}080\,(1.816)(6)}{17.667\,(15.667)^2} \pm \frac{282{,}080(-0.589)(6)}{15.667\,(17.667)^2}$$

$$= 1{,}019.12 \text{ psf} \pm 708.77 \text{ psf} \mp 203.86 \text{ psf}$$

514 psf 1,931.75 psf



1106 psf 1,524 psf

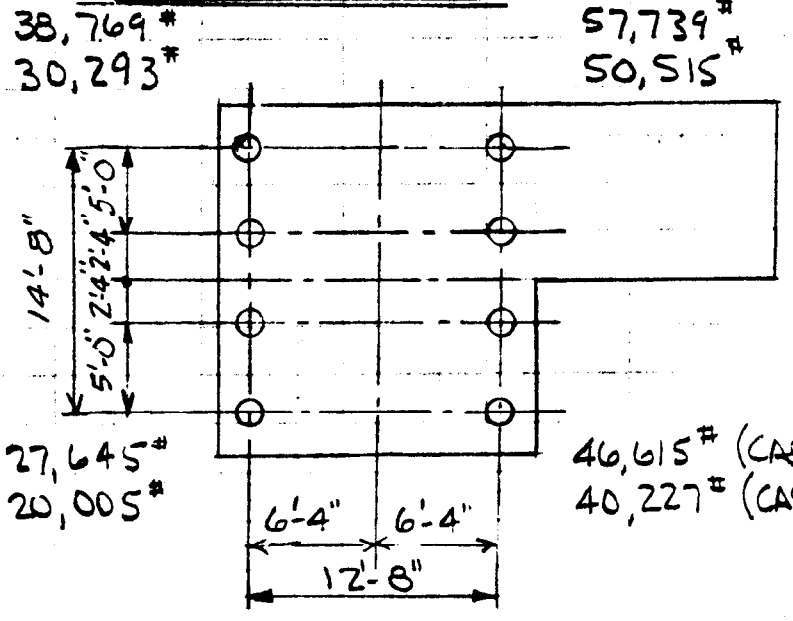
ALSO SEE SHT. PS 20

Subject	ANDALUSIA SLOUGH - PUMP STATION	Date 23 JUNE 82
Computed by KEW	Checked by chJ	Sheet PS 20 of

REVISED 19 OCT. 82

STABILITY

PILE LOADS



$A = 8$

$I_Y = 8(6.333)^2$

$= 320.85$

$I_X = 4(7.333)^2$

$+4(2.333)^2$

$= 236.86$

LOAD CASE I NORMAL CONDITIONS

$$\frac{P}{A} \pm \frac{P e_Y C_Y}{I_Y} \pm \frac{P e_X C_X}{I_X}$$

$$= \frac{341,534}{8} \pm \frac{341,534(1.407)(6.333)}{320.85} \pm \frac{341,534(-0.526)(7.333)}{236.86}$$

$= 42,692 \pm 9,485 \mp 5,562 = 46,615^{\#}; 57,739^{\#};$
$27,645^{\#}; 38,769^{\#};$

LOAD CASE II 100 YR. FLOOD CONDITIONS

$$= \frac{282,080}{8} \pm \frac{282,080(1.816)(6.333)}{320.85} \pm \frac{282,080(-0.589)(7.333)}{236.86}$$

$= 35,260 \pm 10,111 \mp 5,144 = 40,227^{\#}; 50,515^{\#};$
$20,005^{\#}; 30,293^{\#}$

Subject	ANDALUSIA SLOUGH - PUMP STATION	Date 24 OCT. 85
Computed by KEW	Checked by chJ	Sheet PS20a of

STABILITY

CHECK SLIDING

CASE I (NORMAL)

WIND	5,460#
EARTH - ACTIVE	24,462
	29,922#
EARTH - PASSIVE	38,172#
PILES 8 (1,500)	12,000
	50,172#

$$F.S. = \frac{50,172}{29,922} = 1.68$$

CASE II - (100 YR.)

WIND	2,000#
RIVER FLOW	9,803
EARTH - ACTIVE	16,249
	28,052#
EARTH - PASSIVE	38,172#
PILES 8 (1,500)	12,000
	50,172#

$$F.S. = \frac{50,172}{28,052} = 1.79$$

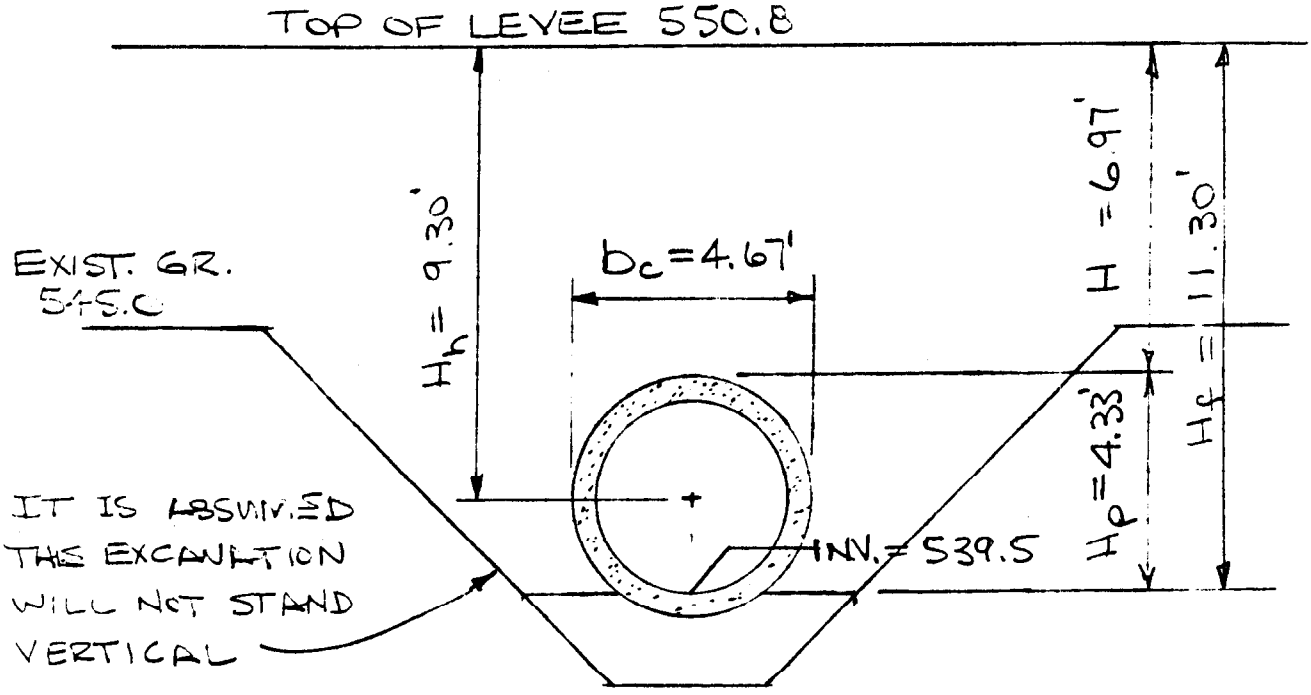
BATTER RIVERWARD PILES

Subject		Date
WILLOW SLOUGH - PUMP STATION		22 SEPT. 8
Computed by: KEV	Checked by: CHJ	Sheet: 15 21 of

PIPE DESIGN AND SUPPORT

REF. (A) CONDUITS, CULVERTS AND PIPES, EM 1110-2-2902, 3 MAR. 1969

(B) CRETEX CONCRETE PRODUCT CAT. 1972



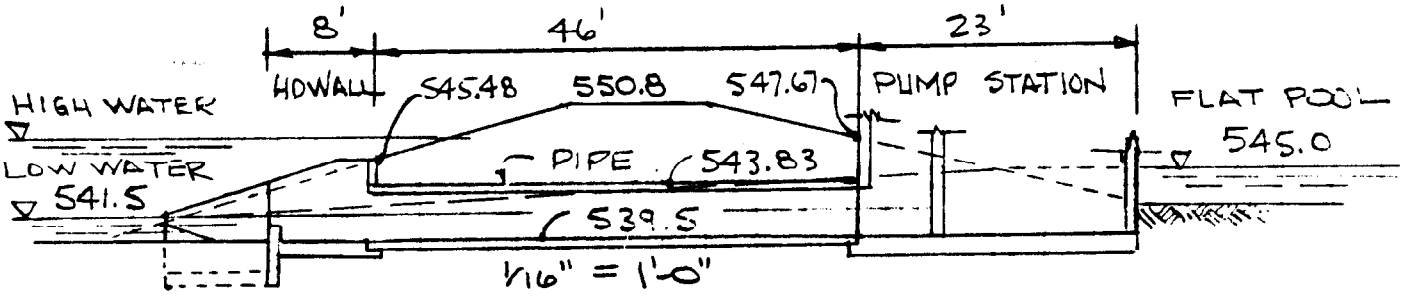
SECTION THRU PIPE AT PUMP STATION.

LOAD CONDITION III - REF. (A)

CASE 1.	CASE 2.
$We = 1.5 \gamma b_c H_h$	$We = \gamma b_c H_h$
$p_e = 0.5 \gamma H$	$p_e = \gamma H$

Subject		Date
ANDALUSIA SLOUGH - PUMP STATION		22 SEPT. 82
Computed by KEW	Checked by chJ	Sheet PS 22 of

PIPE DESIGN AND SUPPORT



EARTH LOAD

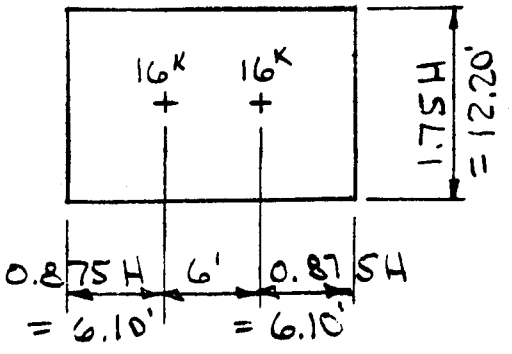
$We_{MAX.} = 1.5(0.115)(4.67)(9.30) = 7.492$ KLF

OR

$We_{MIN.} = 0.115(4.67)(3.98) = 2.137$ KLF

LIVE LOAD

H20 TRUCK = 16.0^K POINT LOAD AT 6'x14' SPC'G.



$$US_{LL} = \frac{2(16.0)}{12.20(18.20)} = 0.144 \text{ KSF}$$

$$W_{LL} = W_{LL}(b_c) = 0.144(4.67) = 0.672 \text{ KLF}$$

Subject ANDALUSIA SLOUGH - PUMP STATION		Date 23 SEPT. 88
Computed by KEV	Checked by CM	Sheet PS23 of

PIPE DESIGN AND SUPPORT

WATER LOAD

LOW WATER CONDITION (MAX. LOAD)

A. PIPE HALF FULL OF WATER.

B. WATER OUTSIDE OF PIPE IS APPROX. AT TOP OF PIPE AT PUMP STATION AND 1'-0" BELOW TOP OF PIPE AT HEAD WALL

$$W_{H_2O} = \pi \left(\frac{2.0}{2}\right)^2 (0.0624) = 0.392 \text{ KLF}$$

$$W_{BOUY} = 0.0624\, b_c H_w = 0.0624(4.67)(4.67 - 0.50)$$

$$= 1.215 \text{ KLF}$$

DEWATERED CONDITION (MIN. LOAD)

A. PIPE EMPTY

B. WATER OUTSIDE OF PIPE AT 545.0 FOR LENGTH OF PIPE

$$W_{BOUY} = 0.0624\, b_c (545.0 - 539.17) = 0.0624(4.67)(5.83)$$

$$= 1.699 \text{ KLF}$$

Subject ANCHORAGE SLOUGH - PUMP STATION		Date 26 SEPT. 88
Computed by KEN	Checked by ch	Sheet PS 24 of

PIPE DESIGN AT SUPPORT

TOTAL LOADS

LOAD	MAXIMUM	MINIMUM
EARTH	7.492 KLF	2.137 KLF
LIVE	0.672	—
	8.164 KLF	
PIPE WT. $0.145\pi\,[(2.33)^2-(2.00)^2]$	0.651	0.651
WATER	0.392	—
	9.207 KLF	2.788 KLF
BOUYANCY	−1.215	−1.699
	7.992 KLF	1.089 KLF

CHECK F.S. AGAINST UPLIFT

$$F.S. = \frac{2.788}{1.607} = 1.64 > 1.50$$ OKAY FOR TEMPORARY

SELECT CLASS OF ASTM PIPE (REF. B)

$$D_{.01} = \left(\frac{W_E}{L_{fE}} + \frac{W_L}{L_{fL}}\right)\frac{S_{f01}}{D}$$

GIVEN:

PIPE SIZE = 48" ($b_c = 4.67'$)
BEDDING CLASS = A OR C
PROJECTION RATIO = 0.90 CLASS A
= 0.90 OR 0.70 CLASS C
SETTLEMENT RATIO = 1.00 CLASS A
0.30 CLASS C

Subject	ANDALUSIA SLOUGH - PWT F STEEL	Date	26 SEPT. 88
Computed by	KEV	Checked by	clv
		Sheet	PS25 of

PIPE DESIGN AND SUPPORT

GIVEN: (CONT.)

SAFTY FACTOR = 1.00 (0.01" CRACK)

FIND LOAD FACTOR FROM PAGE D-25

$\frac{H}{b_c} = \frac{6.97}{4.67} = 1.493$ SAY 1.50

		P=0.9	P = 0.70	USE
CLASS "A"	L_f =	4.49	—	4.00
"C"	L_f =	2.16	1.99	2.00

FIND PIPE CLASS FOR "A" OR "C" BEDDING

CLASS "A" BEDDING

$D_{.01} = \frac{8.164}{4.00}\frac{(1.0)}{(4.0)} = 0.510^{K} = 510^{\#}$

CLASS 1 PIPE D-LOAD = 800#

CLASS "C" BEDDING

$D_{.01} = \frac{8.164}{2.00}\frac{(1.0)}{(4.0)} = 1.020^{K} = 1,020^{\#}$

CLASS 3 PIPE D-LOAD = 1350#

Subject		Date
ANCHORAGE SLOUGH - PUMP STATION		26 SEPT. 8
Computed by KEM	Checked by CHJ	Sheet PS-26

PIPE DESIGN AND SUPPORT

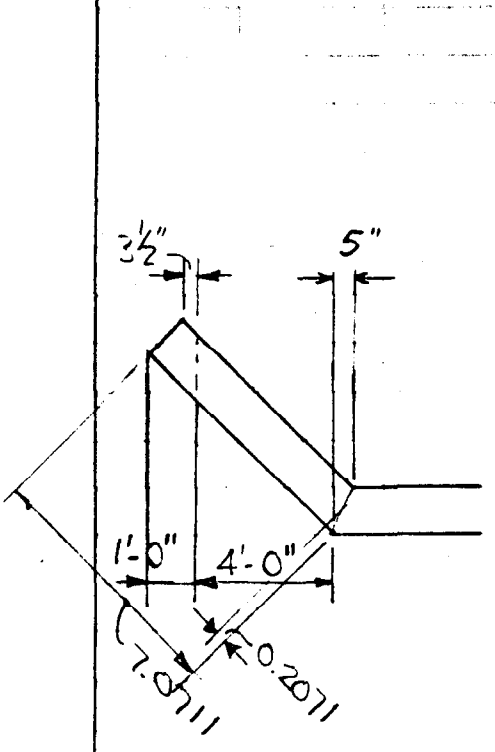
NOTE: CLASS "A" BEDDING WAS USED FOR PIPE SUPPORTED ON PILES.

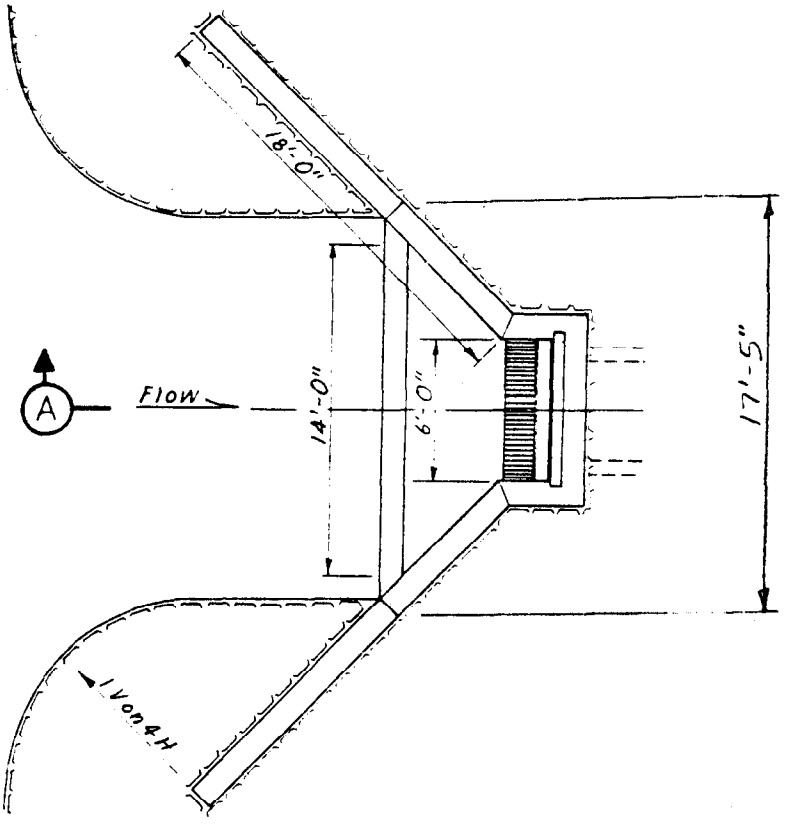
THE SOILS ARE SUCH THAT THE PUMP STATION SHOULD BE SUPPORTED ON PILES. IN ORDER TO CONTROL DIFFERENTIAL SETTLEMENT BETWEEN THE PIPE AND PUMP STATION THE PIPE IS ALSO SUPPORTED ON PILES. SEE SHEET PF-5.

Subject	ANDALUSIA SLOUGH - PUMP STA. HEADWALL	Date	24 JUNE 85
Computed by	KEW	Checked by	CHJ
		Sheet	HW. 1 of

STABILITY

HEADWALL CNTR



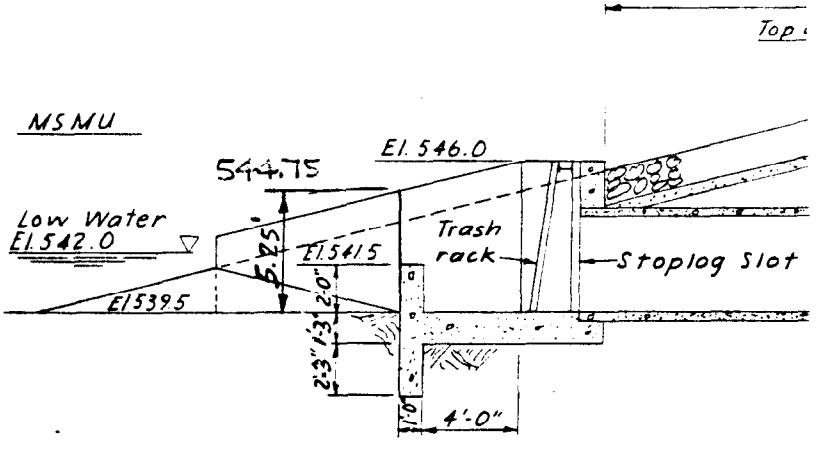


BACKFILL MAT'L.

$\gamma_{DAMP} = 115$ pcf

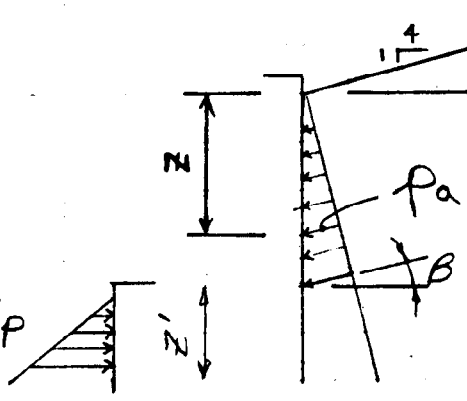
$c = 0$

$\phi = 32°$



Subject		Date
ANDALUSIA SLOUGH - PUMP STA. HEADWALL		24 JUNE 85
Computed by KEW	Checked by CHJ	Sheet HW.3 of

STABILITY HEADWALL CNTR.



$$K_a = \cos\beta \left[\frac{\cos\beta - \sqrt{\cos^2\beta - \cos^2\phi}}{\cos\beta + \sqrt{\cos^2\beta - \cos^2\phi}} \right]$$

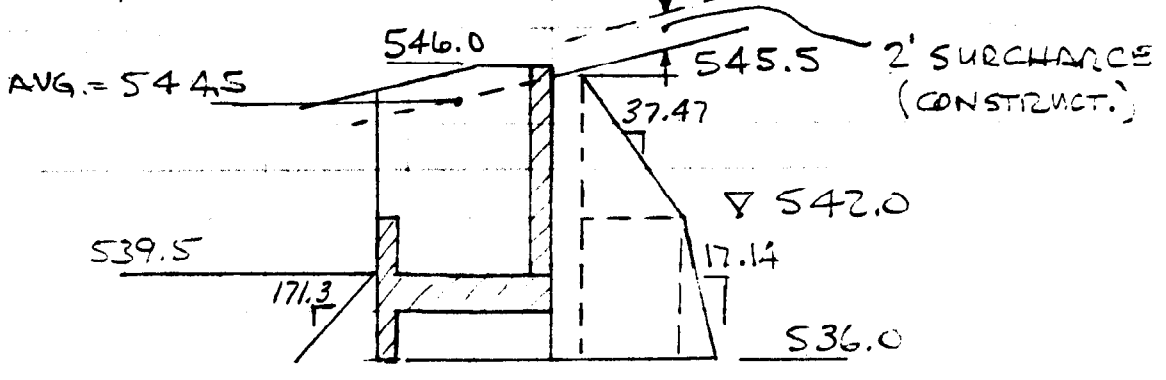
$$K_a = 0.97014 \left[\frac{0.97014 - \sqrt{(0.97014)^2 - (0.84805)^2}}{0.97014 + \sqrt{(0.97014)^2 - (0.84805)^2}} \right]$$

$$= 0.97014 \left(\frac{0.97014 - 0.47115}{0.97014 + 0.47115} \right) = 0.97014 \left(\frac{0.47899}{1.44129} \right)$$

$$= 0.33587$$

$$K_{a_H} = 0.97014 (0.33587) = 0.32584$$

$$K_p = \tan^2\left(45 + \frac{\phi}{2}\right) = \tan^2(61) = 3.255$$



Subject		Date
ANDALUSIA SLOUGH - PUMP STA. CANTILEVER WALL		24 JUNE 8[illegible]
Computed by: KEW	Checked by: CW	Sheet [illegible] of

STABILITY CANTILEVER WALL

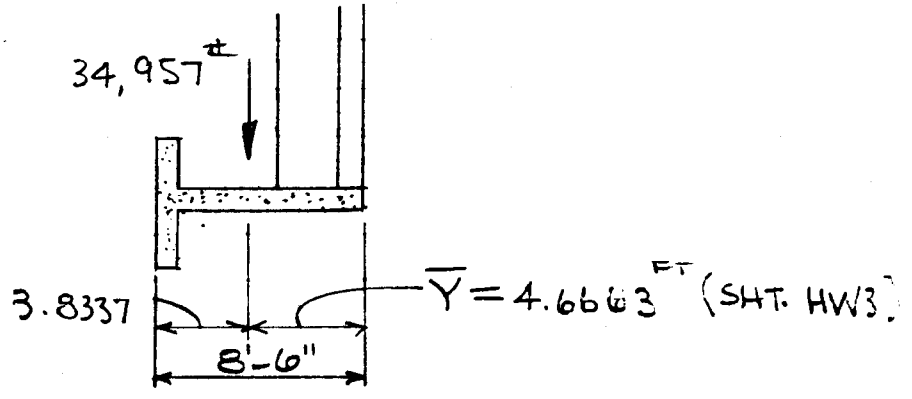
UNIT	FORCE	ARM	MOMENT
WALLS 1.00(150)(8.0)(6.5)	7,800	0.50	3,900
-1.00(150)(π)(4.0)²÷4	- 1,884	0.50	- 942
1.00(150)(2.29)(6.5)2	4,466	2.145	9,580
1.00(150)(15.00)(5.5)	12,375	8.00	99,000
1.00(150)(6.86)(5.25)2	10,805	6.00	64,830
1.00(150)(6.86)(1.25)/2 2	1,286	5.167	6,645
BASE 1.25(150)(8.0)(7.5)	11,250	3.75	42,188
1.25(150)(4.4167)(4.4167)/2 2	3,658	6.028	22,043
WATER 2.50(62.4)(6.00)(7.5)	7,020	3.750	26,325
2.50(62.4)(4.00)(4.00)/2 2	2,496	6.1667	15,392
0.50(62.4)(1.00)(15.0)	468	8.00	3,744
UPLIFT -3.75(62.4)(8.00)(7.5)	-14,040	3.750	- 52,650
-3.75(62.4)(4.4167)(4.4167)/2 2	- 4,565	6.028	- 27,518
-6.00(62.4)(1.00)(16.5)	- 6,178	8.00	- 49,424
	# 34,957	4.6653	FT-# 163,118
EARTH LOADS (NORNAL)(SHT. HWZ)			
ACTIVE			
37.47(2.0)(9.50)(8.00)	5,695	4.75	27,051
37.47(2.0)(8.50)(17.4142-8.0)	5,997	4.25	25,487
37.47(3.5)(3.5/2)(6.00)	1,836	7.167	13,159
37.47(2.5)(2.5/2)(17.4142-8.0)	1,102	6.833	7,532
37.47(3.5)(6.0)(8.00)	6,295	3.00	18,885

Subject		Date
ANDALUSIA SLOUGH - PUMP STA. HEADWALL		24 JUNE 85
Computed by KEW	Checked by chJ	Sheet HW 4 of

STABILITY HEADWALL CNTR.

UNIT	FORCE	ARM	MOMENT
ACTIVE (CONT.)			
$37.47\,(2.50)(6.00)(17.4142-8.0)$	5,291	3.00	15,873
$17.14\,(6.00)\left(\frac{6.00}{2}\right)(17.4142)$	5,373	2.00	10,746
$-37.47\,(5.50)(\pi)(2.5)^2$	-4,046	6.00	- 24,276
	27,543 #		94,455 FT-#
PASSIVE			
$171.3\,(3.50)\left(\frac{3.50}{2}\right)(17.4142)$	-18,271 #	1.1667	- 21,317 FT-#

CHECK OVERTURNING F.S. 30 JUNE 85



$M_R = 34,957\,(3.8337) + M_{PASSIVE}$

$= 134,016 + 21,317 = 155,333$ FT-#

$M_O = M_{ACTIVE} = 94,455$ FT-#

$F.S. = \frac{M_R}{M_O} = \frac{155,333}{94,455} = 1.64 > 1.50$ OKAY

Subject	ANDALUSIA SLOUGH - PUMP STA. HEADWALL	Date 30 JUNE 8
Computed by KEN	Checked by chd	Sheet HW.5 of

STABILITY - HEADWALL CNTR.

CHECK SLIDING

$P_{ACTIVE} = 27,543^{\#}$

$P_{PASSIVE} + \mu P_{VERT} = 18,271 + 0.30(34,957)$

$= 28,758^{\#}$

$F.S. = \frac{28,758}{27,543} = 1.05 < 1.5$ NO GOOD

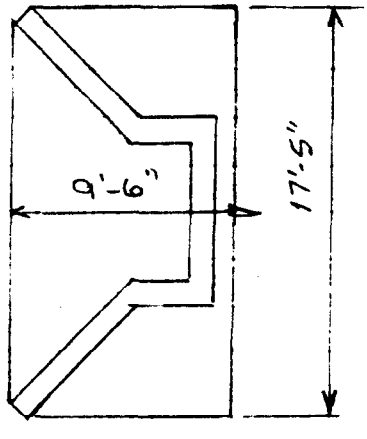
WITHOUT CONSTRUCTION SURCHARGE

$P_{ACTIVE} = 27,543 - (5,695 + 5,997)$

$= 15,851^{\#}$

$F.S = \frac{28,758}{15,851} = 1.82 < 2.0$ NO GOOD

INCREASE BASE TO INCREASE VERT. LOAD



Subject	ANDALUSIA SLOUGH - PUMP STA. HEADWALL	Date	30 JUNE 88
Computed by	Checked by	Sheet	HW 6 of

STABILITY HEADWALL CNTR.

RECOMPUTED LOADS

UNIT		FORCE	ARM	MOMENT
ADDED	$1.25(150)(1.0)(17.4142)$	3,265	-0.50	- 1,633
BASE	$1.25(150)(2.4167)(17.4142-8.0)$	4,266	1.2084	5,155
	$1.25(150)(4.7071)(\frac{4.7071}{2})2$	4,154	3.9857	16,557
ADDED	$6.0(115)(1.0)(17.4142)$	12,016	-0.50	- 6,008
EARTH	$-115(\pi)(2.5)^2(1.0)$	- 2,258	-0.50	1,129
	$5.6(115)(2.4167)(17.4142-8.0)$	14,652	1.2084	17,705
	$4.8(115)(4.7071)(\frac{4.7071}{2})2$	12,231	3.9857	48,749
ADDED	$-3.75(62.4)(1.0)(17.4142)$	- 4,075	-0.50	2,038
UPLIFT	$-3.75(62.4)(2.4167)(17.4142-8.0)$	- 5,324	1.2084	- 6,434
	$-3.75(62.4)(4.7071)(\frac{4.7071}{2})2$	- 5,185	3.9857	- 20,666
PREVIOUS VERT. LOADS		34,957	4.6663	163,118
		68,699 #	3.1982	219,710 Ft-#
EARTH LOADS				
ACTIVE				
	$37.47(2.0)(9.75)(17.4142)$	12,724	4.875	62,030
	$37.47(3.75)(\frac{3.75}{2})(17.4142)$	4,588	7.250	33,263
	$37.47(3.75)(6.00)(17.4142)$	14,681	3.00	44,043
	$17.14(6.00)(\frac{6.00}{2})(17.4142)$	5,373	2.00	10,746
	$-37.47(5.75)(\pi)(2.5)^2$	- 4,230	6.00	- 25,380
		33,136 #		124,702 Ft-#
PASSIVE (SEE SHT. HW 4)		-18.271 #	1.1667	- 21.317 Ft-#

Subject		Date
ANDALUSIA SLOUGH - PUMP STA. HEADWALL		30 JUNE 88
Computed by KEW	Checked by CAJ	Sheet HW7 of

STABILITY - HEADWALL CNTR

RE-CHECK SLIDING

$P_{ACTIVE} = 33{,}136^{\#}$

$P_{PASSIVE} + \mu P_{VERT} = 18{,}27. + 0.30(68{,}699)$

$= 38{,}881^{\#}$

$F.S. = \frac{38{,}881}{33{,}136} = 1.17 < 1.50$ NO GOOD

WITHOUT CONSTRICTION SURCHARGE

$P_{ACTIVE} = 33{,}136 - 12{,}724 = 20{,}412^{\#}$

$F.S. = \frac{38{,}881}{20{,}412} = 1.90 < 2.00$ ALMOST GOOD ENOUGH

CHECK BEARING PRESSURES

$P_V = 68{,}699^{\#}$ $\Sigma M = 323{,}095^{FT-\#}$

$\bar{Y} = 4.703^{FT}$

$e = 4.703 + 1.00 - \frac{9.50}{2} = 0.953^{FT} < \frac{9.5}{6}$

< 1.58

Subject ANDALUSIA SLOUGH - PUMP STA. HEADWALL		Date 30 JUNE 88
Computed by KEW	Checked by chJ	Sheet H-1.8 of

STABILITY - HEADWALL CNTR.

$$\frac{P}{A} \pm \frac{M_{ey}}{S_y} = \frac{68,699}{9.5(17.4142)} \pm \frac{68,699(0.953'6)}{(9.5)^2(17.4142)}$$

$$= 415.3 \pm 249.9 = 665.2 \text{ psf}$$

OR

$$165.4 \text{ psf}$$

NOTE: ALTHOUGH BEARING APPEARS TO BE NO PROBLEM, SLIDING IS. PROVIDING TIE RODS BETWEEN THE PUMP STATION AND THE HEADWALL CNTR. WILL PREVENT SLIDING.

$$F = \frac{33,136}{2} = 16,568^{\#/\text{ROD}}$$

USED BATTERED PILES

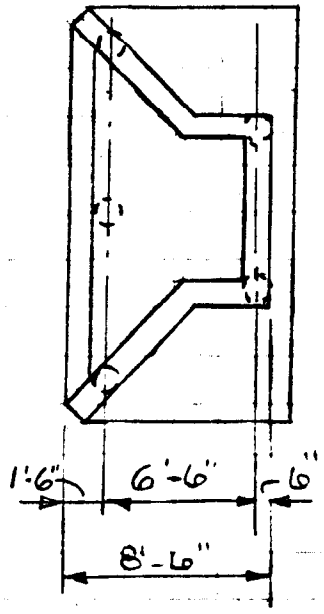
PROVIDE 2-1"ϕ A 522, GR. 50 RODS W/ TURNBUCKLES

CONSIDER PILE FOUNDATION WITH BATTERED (4:1) FRONT PILES)

Subject	ANDALUSIA SLOUGH-PUMP STA. HEADWALL	Date 30 JUNE 88
Computed by KEW	Checked by CHJ	Sheet HW9 of

STABILITY - HEADWALL CNTR.

PILE LOADS - 5 PILES



$A = 5$

$$C = \frac{2(0) + 3(6.5)}{5}$$

$$= 3.90 \text{ FT}$$

$$I = 2(3.90)^2 + 3(2.6)^2$$

$$= 30.42 + 20.28$$

$$= 50.70 \text{ FT}^2$$

$$e = \bar{Y} - C = 4.703 - 3.90$$

$$= 0.803 \text{ FT}$$

$$\frac{P}{A} \pm \frac{PeC}{I} = \frac{68,699}{5} \pm \frac{68,699\,(0.803)(2.6 \text{ OR } 3.9)}{50.70}$$

$$= 13,740 + 2,829 = 16,569^{\#}$$
$$- 4,244 \quad \text{OR} \quad 9,496^{\#}$$

PILE LOADS - 3 PILES

$A = 3$ $\qquad C = \frac{1(0) + 2(6.5)}{3} = 4.333 \text{ FT}$

Subject ANDALUSIA SLOUGH-PUMP STA. HEADWALL		Date 30 JUNE 88
Computed by KEN	Checked by	Sheet H.W.C

STABILITY - HEADWALL CNTD.

$$I = 1(4.333)^2 + 2(2.167)^2$$

$$= 18.77 + 9.39 = 28.16 \text{ FT}^4$$

$$e = \bar{Y} - C = 4.703 - 4.333 = 0.370 \text{ FT}$$

$$\frac{P}{A} \pm \frac{PeC}{I} = \frac{68,699}{3} \pm \frac{68,699(0.370)(2.167 \text{ or } 4.333)}{28.16}$$

$$= 22,900 + 1,956 = 24,856^{\#}$$
$$- 3,911 \quad \text{or} \quad 18,989^{\#}$$

Subject ANDALUSIA SLOUGH - PUMP STATION		Date 20 SEPT. 88
Computed by KEW	Checked by chJ	Sheet PF-1 of

PILE FOUNDATION DESIGN

REF: ① FOUNDATION DESIGN, WAYNE C. TENG, 1962

② FOUNDATIONS & EARTH STRUCTURES, NAVFAC DM-7.2, MAY 1982

PUMP STATION (SEE SHT. PS-20)

PILE LOAD = 57,739# = 28.87 TON (RIVERSIDE R...

FOR BATTERED PILE (4:1), F = 1.031 (28.87)

= 29.76 TON

FROM BORING A-88-2

a.) PILES DRIVEN INTO MEDIUM TO FINE SAND WITH BLOW COUNT OF 8 BLOWS/FT

b.) DEPTH OF BORING IS ONLY 16' BELOW BOTTOM OF PUMP STATION

$\Phi = 35°$; $\gamma = 115$ pcf REF. ①, page 12

$N_q = 40$; $N_\gamma = 45$ REF. ①, page 58

$$Q_{ULT} = \pi R_T^2 (\gamma D N_q + 0.6 \gamma R_T N_\gamma) + 2\pi R_A L (\gamma Z + q_L) K \tan\Phi$$

REF. ① Eq. (8-1) + Eq. (8-2) pg. 212 & 213

Subject		Date
ANDALUSIA SLOUGH - PUMP STATION		20 SEPT. 82
Computed by KEW	Checked by CAV	Sheet PF-2 of

PILE FOUNDATION DESIGN

WHERE: R_T = RADIUS OF PILE TIP
R_A = AVG. RADIUS OF PILE
γ = UNIT WEIGHT OF SOIL (BOUYANT WT.)
D = TOTAL PENETRATION OF PILE
L = LENGTH OF PENETRATION INTO GRANULAR SOIL.
z = DEPTH OF CENTER OF GRAVITY OF EMBEDDED PORTION OF PILE.
q = PERMANENT SURCHARGE LOAD.
K = COEFFICIENT OF LATERAL EARTH PRESSURE (ASSUME 1.25) REF. ②, pg 7.2-194

ASSUME
40 FT. PENETRATION INTO GRANULAR SOIL
47.5 FT. TOTAL PENETRATION (50 FT PILE)
44" BUTT CIRCUM. 7.00 RADIUS
22 TIP CIRCUM. 3.50 RADIUS
33 AVG. CIRCUM. 5.25 RADIUS

$$Q_{ULT_S} = \pi \left(\frac{3.50}{144}\right)^2 \left[(115 - 62.5)(40) + 0.6\,(115 - \overset{52.5}{62.5})\left(\frac{3.50}{12}\right)(45)\right]$$
$$+ 2\pi \left(\frac{5.25}{12}\right)(40)\left[(115 - \overset{52.5}{62.5})\left(\frac{40}{2} + 7.5\right)\right](1.25)(\tan 35)$$
$$= 672 + 138{,}945 = 139{,}617^{\#}$$

CALCULATE REDUCTION DUE TO GROUP ACTION

NOTE: SEE PS-20, PILES ARE FAR ENOUGH APART IN ONE DIRECTION (7 DIAM) TO BE CONSIDERED A SINGLE ROW GROUP. REF. ② pg 7.2-204

Subject	LINDALUSIA SLOUGH - PUMP STATION	Date 20 SEPT. 88
Computed by KEV.	Checked by CHJ	Sheet PF-3 of

PILE FOUNDATION DESIGN

REF. (3) DESIGN OF PILE FOUNDATIONS AND STRUCTURES, EM 1110-2-2906

$$F = 1 - \left(2 - \frac{1}{n} - \frac{1}{m}\right)\frac{\theta}{90}$$ REF. (3), fig 11

WHERE F = EFFICIENCY FACTOR OF A PILE IN A GROUP

n = NUMBER OF PILE IN A GRP.

m = NUMBER OF ROWS

$\theta = \tan^{-1}\frac{d}{s}$

d = PILE DIAM.

s = PILE SPACING

$$F = 1 - \left(2 - \frac{1}{4} - \frac{1}{1}\right)\frac{\tan^{-1}\left(\frac{10.50}{12}/4.667\right)}{\theta_c}$$

$= 0.9115$

$\therefore Q_{ULT_G} = 139{,}617\,(0.9115) = 127{,}262^{\#} = 63.63^{T}$

ASSUME 5 TON NEG FRICTION DUE TO DRIVING OF ADJACENT PILES

ALSO ASSUME F.S. = 2.0

Subject ANDALUSIA SLOUGH - PUMP STATION		Date 20 SEPT. 89
Computed by KEW	Checked by clv	Sheet PF-4 of

PILE FOUNDATION DESIGN

PILE CAPACITY

$$Q = \frac{Q_{ULT_G}}{F.S.} - 5.00 = \frac{63.63}{2.0} - 5.00$$

$$= 26.82^{TON} < 29.76^{TON}\ REQ'D$$

11.0% UNDER DESIGNED

CONSIDERED OKAY BECAUSE THE PILE BEING CONSIDERED IS THE LAST ONE IN THE ROW AND THE ONE WITH THE MAX LOAD. ALSO OVERTURNING IN THE TRANSVERSE DIRECTION WILL BE RESISTED BY EARTH.

PILE LOAD = 38,769# = 19.38 TON (LANDSIDE ROW)

ASSUME 35 FT PENETRATION INTO GRANULAR SOIL (45 FT PILE / 44" BUTT & 24" T.P.)

$$Q_{ULT_S} = \pi\left(\frac{3.82}{144}\right)^2\left[(115-62.5)(40) + 0.5(115-62.5)\left(\frac{3.82}{12}\right)(40)^2\right]$$

$$+ 2\pi\left(\frac{5.41}{12}\right)(35)\left[(115-62.5)\left(\frac{35}{2}+7.5\right)\right](1.25)(\tan 35)$$

$$= 812 + 113,894 = 114,706^{\#}$$

$$Q_{ULT_G} = 114,706\,(0.9115) = 104,554^{\#} = 52.28^{TON}$$

Subject	ANCHALUSIA SLOUGH - PUMP STATION	Date 20 SEPT. 89
Computed by KEW	Checked by clv	Sheet PF-5 of

PILE FOUNDATION DESIGN

PILE CAPACITY

$$Q = \frac{Q_{ULTG}}{F.S.} - 5.00 = \frac{52.28}{2.0} - 5.00$$

$$= 21.14^{TON} > 19.38^{TON}$$

PIPE SUPPORT (SEE SHT. PS 24)

PILE LOAD $= 7,992(3.5) = 27,972^{\#}$ OR 13.99^{TON}

NOTE: 30^{FT} PENETRATION (40 FILE) SHOULD PROVIDE ENOUGH SUPPORT

HEADWALL (SEE SHT. HW1C)

PILE LOAD $= 24,856^{\#} = 12.43^{TON}$

FOR BATTERED PILE (4:1), $P = 1.031(12.43)$

$$= 12.82^{TON}$$

ASSUME 25^{FT} PENETRATION INTO GRANULAR SOIL
(30^{FT} PILE/44" BUTT ± 27" TIP)

$$Q_{ULTS} \simeq 963 + 2\pi\left(\frac{5.65}{12}\right)(25)\left[(115-62.5)\left(\frac{25}{2}+7.5\right)\right](1.5)(\tan 30)$$

$$= 963 + 67,969 = 68,932^{\#} \text{ OR } 34.46^{TON}$$

Subject		Date
ANDALUSIA SLOUGH - PUMP STATION		20 SEPT. 89
Computed by KEW	Checked by CHJ	Sheet PF-6 of

PILE FOUNDATION DESIGN

PILE CAPACITY

$$Q = \frac{Q_{ULTS}}{F.S.} - 5.00 = \frac{34.46}{2} - 5.00$$

$$= 12.23^{TON} \simeq 12.82^{TON}$$

4.8% UNDER DESIGN

Subject	ANDALUSIA SLOUGH – PUMP STATION	Date 4 MAY 82
Computed by KEW	Checked by CHJ	Sheet MISC.1 of

TRASH RACK DESIGN

EM 1110-2-3104

DESIGN FOR DIFFERENTIAL HEAD OF 5 FT. DUE TO TRASH BUILD-UP.

EM 1110-2-3102

BAR SPACING 1 3/4" INCHES CLEAR (3" MAX. IF JUSTIFIED)

FLOW THRU GROSS RACK AREA $\leq$ 2.5 FT/SEC.

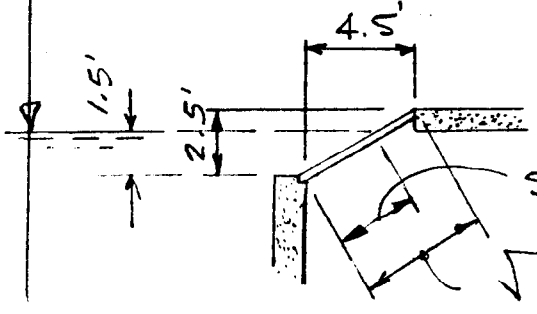
PUMPING RATE = 10,000 GPM

$= \frac{10,000}{7.48} = 1,337$ CU. FT/MIN

$= \frac{1,337}{60} = 23$ CU. FT/SEC

RIVER SIDE TRASH RACK

$A = {}^{\text{WIDTH}}5.00(3.083) = 15.44$ FT^2



$V = \frac{23}{15.44} = 1.49$ FT/SEC

$5.148\left(\frac{1.5}{2.5}\right) = 3.089$ FT

$\sqrt{4.5^2+2.5^2} = 5.148$ FT

Subject		Date
ANDALUSIA SLOUGH - PUMP STATION		4 MAY 88
Computed by KEW	Checked by chJ	Sheet MISC 2 of

TRASH RACK DESIGN

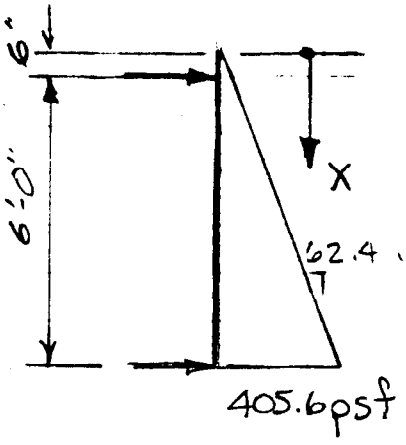
LANDSIDE TRASH RACK

$A = \underset{\text{WIDTH}}{6.00}\ (\underset{H_2O\ \text{DEPTH}}{2.00}) = 12.00\ FT^2$

$V = \frac{23}{12} = 1.92\ FT/SEC.$

6'-6" HEAD

$R_{TOP} = 405.6\left(\frac{6.5}{2}\right)\left(\frac{6.5}{3}\right)\left(\frac{1}{6.0}\right) = 476.0\ ^{\#}$



$R_{BOTT.} = 405.6\left(\frac{6.5}{2}\right)\left[\frac{2}{3}(6.5) - 0.5\right]\left(\frac{1}{6.0}\right) = 842.2\ ^{\#}$

$V = 0 = 476.0 - 62.4(X)\left(\frac{X}{2}\right)$

$X = 3.906\ FT.$

$M = 476.0\ (3.906 - 0.50) - 62.4\left(\frac{3.906}{6}\right)^3$

$= 1,621.2 - 619.8 = 1,001.5\ ^{FT-\#/FT}$

$= 12,017.8\ ^{IN-\#/FT}$

ASSUME 2" BAR SPACING $^{3/8"}$ BAR + $1\frac{5}{8}$" CLR.

$M = 2,003.0\ ^{IN-\#/BAR}$

Subject	ANDALUSIA SLOUGH - PUMP STATION	Date 4 MAY 88
Computed by KEW	Checked by chJ	Sheet MISC 3 of

TRASH RACK DESIGN

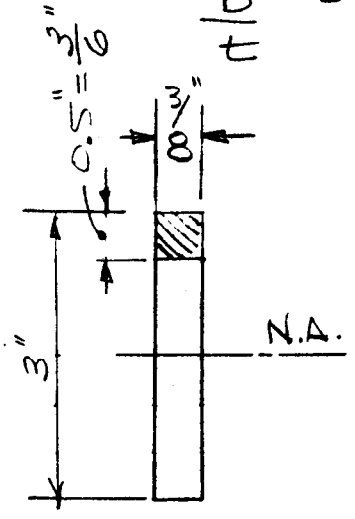
TRY 3" x 3/8" BAR

$$S = \frac{3/8\,(3.0)^2}{6} = 0.5625\ IN^3$$

$$f_b = \frac{2,003.0}{0.5625} = 3,561\ psi$$

ASSUME BAR NETS AS STEM OF TEE

$$\frac{b}{t} = \frac{2.5}{0.375} = 667 < \frac{127}{\sqrt{F_y}} = 21$$



$$r_T = \sqrt{\frac{I}{A}} = \sqrt{\frac{0.5(0.375)^3}{\frac{12}{0.5\,(0.375)}}}$$

$$= 0.10825\ IN$$

$$\frac{\lambda}{r_T} = \frac{8.5\,(12)}{0.10825} = 942.2$$

AISC 1.5.1.4.5

$$\sqrt{\frac{510 \times 10^3}{F_y}} = 119.0 < \frac{\lambda}{r_T}\ ;\ \therefore F_b = \text{LARGER OF BELOW}$$

$$F_b = \frac{170 \times 10^3}{\left(\frac{\ell}{r_T}\right)^2} = \frac{170 \times 10^3}{(942.2)^2} = 0.192\ KSI$$

OR

Subject	ANDALUSIA SLOUGH - PUMP STATION	Date 4 MAY 88
Computed by KEW	Checked by CHN	Sheet MISC. 4 of

TRASH RACK DESIGN

$$F_b = \frac{12,000}{\frac{\ell d}{Af}} = \frac{12,000\,(0.5)(0.375)}{8.5(12)(3.0)}$$

$$= 7.353 \text{ KSI} > f_b = 3.561 \text{ KSI}$$

BEARING BEAM

ASSUME 1,000 #/FT LOAD (NO GUIDE)

$$M = 1,000\left(\frac{6.00}{8}\right)^2 = 4,500 \text{ FT/\#}$$

$$S = \frac{4,500(12)}{24,000} = 2.25 \text{ IN}^2 \qquad \text{USE W4} \times 13$$

$$S = 5.46 \text{ IN}^3$$

Subject	ANDALUSIA SLOUGH - PUMP STATION	Date 4 MAY 88
Computed by KEV	Checked by CHJ	Sheet MISC.S of

SIZE CONCRETE PIPE

1. ASSUME PIPE RUNS HALF-FULL
2. SIZE SO THAT VELOCITY IN THE PIPE IS LESS THEN 5.0 FT/SEC.

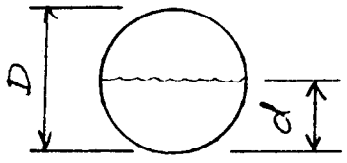
PUMPING RATE = 10,000 GPM

$$= \frac{10{,}000}{448.8} = 22.28 \text{ CU. FT./SEC.}$$

PIPE DIAM	VELOCITY
36"ϕ	$\frac{22.28}{\frac{\pi}{2}(1.5)^2} = 6.30$ FT/SEC.
42"ϕ	$\frac{22.28}{\frac{\pi}{2}(1.75)^2} = 4.63$ FT/SEC. OKAY
48"ϕ	$\frac{22.28}{\frac{\pi}{2}(2.0)^2} = 3.55$ FT/SEC. $\Leftarrow$ USE

SLOPE OF PIPE

$$S = \left[\frac{Qn}{0.232\, D^{8/3}}\right]^2$$



$\frac{d}{D} = 0.50$

L = 48'-0" ±

$$= \left[\frac{22.28(0.015)}{0.232\,(4.0)^{2.667}}\right]^2 = (0.0357)^2 = 0.00128 \text{ FT/FT}$$

$= 0.737$ IN TOTAL

NIL - DO NOT SLOPE PIPE

Subject	ANDALUSIA SLOUGH – PUMP STATION	Date 19 MAY 88
Computed by KEW	Checked by chJ	Sheet RF 1 of

ROOF SLAB (SPAN = 8'-6")

LOADS

SLAB	50 psf
MISC	10
	60 psf

SNOW 30 psf

$d = 4 - 0.75 - 0.25$ (CLR, BAR/2)

$= 3$ IN

ACI 318-83

$W_u = 1.7(30) + 1.4(60) = 135$ psf

$V_{ud} = 135\left(\frac{8.5}{2} - \frac{3}{12}\right) = 540$ #

$M_u = 135\frac{(8.5)^2}{8} = 1{,}220$ FT-#

BALANCED RATIO OF REINFORCEMENT

LET $f_y = 48{,}000$ psi ; $\beta_1 = 0.85$ ACI 10.2.7.3

$f'_c = 3{,}000$ psi

$\frac{X_b}{d} = \frac{87{,}000}{87{,}000 + f_y} = \frac{87{,}000}{135{,}000} = 0.6444$

$\rho_b = 0.85\frac{f'_c}{f_y}\beta_1\frac{X_b}{d} = 0.85\left(\frac{3.0}{48.0}\right)(0.85)(0.6444)$

$= 0.0291$

$0.75\,\rho_b = 0.75(0.0291) = 0.02183$

Subject	ANDALUSIA SLOUGH - PUMP STATION	Date 20 MAY 88
Computed by KEW	Checked by chd	Sheet RF 2 of

ROOF SLAB

DETERMINE DEPTH OF SECTION

$$M_u = \phi \rho f_y b d_b^2 \left(1 - 0.59 \rho \frac{f_y}{f'_c}\right)$$

$$1.220(12) = 0.90(0.02183)(48)(12)(d_b)^2\left[1 - 0.5^{9}(0.02183)\left(\frac{48}{3}\right)\right]$$

$$1.220(12) = 8.984\, d_b^2$$

$$\therefore d_b = \sqrt{\frac{1.220(12)}{8.984}} = 1.28 \text{ IN} \qquad \text{SAY } d = 3 \text{ IN}$$

CHECK SHEAR

$$V_c = 2\sqrt{f'_c}\, bd$$

$$= 2\sqrt{3{,}000}(12)(3) = 3{,}943^{\#}$$

$$\phi V_c = 0.85(3{,}943) = 3{,}352^{\#} > V_{u_d} = 540^{\#}$$

COMPUTE REINFORCING

REF: TECH. REPORT SL-80-4 "STRENGTH DESIGN OF REINFORCED CONCRETE HYDRAULIC STRUCTURES" - REPORT #2

$$\frac{b}{a} = \frac{4}{3} = 1.33 \Leftarrow$$

$f'_c = 3{,}00$ KSI AND $f_y = 48.00$ KSI

Subject	ANDALUSIA SLOUGH - PUMP STATION	Date 20 MAY 82
Computed by KEW	Checked by chJ	Sheet RF3 of

ROOF SLAB

$$\frac{M_N}{bd^2} = \frac{1.220\,(12)}{0.90\,(12)(3.0)^2} = 0.151$$

FIG. 10 $\rho = 0.0033$

$$\rho_{min} = \frac{200}{48{,}000} = 0.00417 > \rho = 0.0033$$

$$> \frac{4}{3}\rho = 0.0044$$

$$\therefore A_S = 0.0044(12)(3)$$

$$= 0.158\ IN^2/FT \qquad \#3 @ 8 = 0.165\ IN^2/FT$$

$$A_{S\,TEMP} = 0.0025\,(12)(4)$$

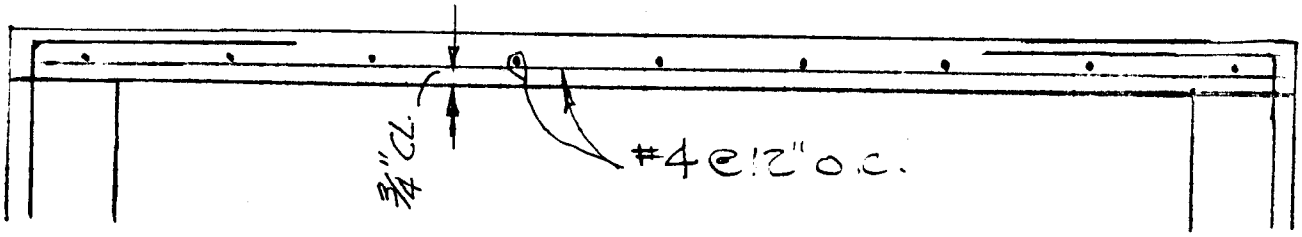
$$= 0.120\ IN^2/FT < A_S$$

$$A_{S\,TEMP\ EDGE} = 0.004\,(12)(4)$$

$$= 0.192\ IN^2/FT > A_S$$

USE #4 @ 12" O.C. EA. WAY

NOTE: BECAUSE THE SLAB IS ONLY 4" THICK USE ONE LAYER OF REINF.



NCR Form 1 Aug 80 381b

APPENDIX E

HYDRAULIC DREDGING - WATER COLUMN DATA

The University of Iowa

Iowa City, Iowa 52242

Civil/Environmental Engineering
Environmental Engineering Laboratories
105 Water Plant
(319) 335-5177

December 24, 1987

Corps of Engineers
Rock Island District
ATTN: CENCR-ED-DG (Holmes)
Clock Tower Building
P.O. Box 2004
Rock Island, Illinois 61204-2004

Dear Mr. Holmes:

Enclosed are the results of the third set of settling column analyses completed in December. Table E-1 is the data obtained using the bulk sample from location 1. This sample was loaded at a concentration of ****** , which is equivalent to 145 grams/liter dry weight. Table F-1 was obtained from the bulk sample from location 2, with a loading concentration of *********, which is equivalent to 145 grams/liter dry weight.

If you have any questions please let me know.

Sincerely,

J. Kent Johnson, Ph. D
Laboratory Director

Table E-1

SEDIMENT STUDY
DECEMBER, 1987

SAMPLE 1

Reference
Boring A-87-2
Typ OH soil
Wc 83% in-situ

TIME (HRS)	SAMPLE PORTS A	B	C	D	E	F	G	G Mudline Core Wc, %
0	128.3	129.1	123.2	126.0	123.0	121.4	119.9	796
.5	123.0	118.2	119.6	123.2	114.0	127.7	156.4	–
1	124.5	123.4	118.2	128.6	119.8	132.3	181.7	–
2	6.3	116.3	115.0	117.6	120.6	174.0	216.0	–
4	1.2	7.4	96.2	114.6	126.6	233.6	232.5	–
6	1.8	2.9	3.2	145.9	248.0	287.0	252.7	–
12	0.4	0.4	0.5	0.4	273.0	295.0	263.6	–
24	0.4	0.6	0.5	0.6	283.0	321.0	300.0	296
DAY								
2	0.2	0.2	0.2	0.2	0.3	334.1	318.7	–
3	0.1	0.1	0.1	0.1	0.2	364.0	374.1	–
4	0.1	0.0	0.1	0.1	0.1	355.5	422.0	–
5	0.0	0.1	0.1	0.0	0.1	225.6	** 477	172
10	0.0	0.0	0.0	0.0	0.0	0.3	** 484	169
15	0.0	0.0	0.0	0.0	0.0	0.0	** –	–

** SAMPLES WERE TOO CONCENTRATED TO RUN SUSPENDED SOLIDS.
THE PERCENT DRY WEIGHTS ARE AS FOLLOWS:

TIME (DAY)	PORT	PERCENT DRY WEIGHT
5	G	36.8
10	G	37.2
15	G	32.5

Table E-2
SEDIMENT STUDY
DECEMBER, 1987

SAMPLE 2

Reference
Boring A-87-2
Typ CL soil
wc = 31-39% in-situ

TIME (HRS)	SAMPLE PORTS A	B	C	D	E	F	G	G Moisture Content, W = %
0	136.4	132.0	135.2	129.4	133.9	138.4	132.5	117
.5	133.8	132.9	127.1	124.6	126.0	139.8	141.8	-
1	116.5	128.0	124.0	136.4	130.5	130.1	140.8	-
2	122.1	124.7	121.9	129.6	126.9	133.6	135.1	-
4	104.3	112.8	117.0	126.1	126.8	129.9	201.8	-
6	0.8	117.4	122.8	124.5	127.1	131.6	247.1	-
12	0.3	0.4	116.7	117.7	120.7	203 1	264.9	-
24	0.2	0.3	5.0	15.9	216.5	241.2	297.0	299
DAY								
2	0.1	0.2	0.2	0.2	241.4	229.2	292.3	-
3	0.1	0.1	0.1	0.1	233.8	255.2	300.8	-
4	0.1	0.1	0.1	0.1	218.8	226.8	291.1	-
5	0.1	0.1	0.1	0.1	221.5	221.8	316.7	278
10	0.0	0.0	0.0	0.0	0.4	260.9	333.2	262
15	*0.0	0.0	0.0	0.0	0.0	0.0	** 568	139

* THIS SAMPLE WAS TAKEN FROM THE SURFACE OF THE WATER COLUMN.

** THE SAMPLE WAS TOO CONCENTRATED TO RUN SUSPENDED SOLIDS. THE PERCENT DRY WEIGHT OF THE SAMPLE IS 42.0.

APPENDIX F

MECHANICAL AND ELECTRICAL CONSIDERATIONS

UPPER MISSISSIPPI RIVER SYSTEM
ENVIRONMENTAL MANAGEMENT PROGRAM
DEFINITE PROJECT REPORT (R-4)

ANDALUSIA REFUGE REHABILITATION AND ENHANCEMENT

POOL 16
MISSISSIPPI RIVER MILE 462 to 463
Rock Island County, Illinois

APPENDIX F
MECHANICAL AND ELECTRICAL CONSIDERATIONS

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List of Plates

UPPER MISSISSIPPI RIVER SYSTEM
ENVIRONMENTAL MANAGEMENT PROGRAM
DEFINITE PROJECT REPORT (R-4)

ANDALUSIA REFUGE REHABILITATION AND ENHANCEMENT

POOL 16
MISSISSIPPI RIVER MILE 462 to 463
Rock Island County, Illinois

APPENDIX F
MECHANICAL AND ELECTRICAL CONSIDERATIONS

Purpose and Scope. The purpose of this appendix is to present preliminary design for the pumping station development at the Andalusia Refuge. Pump manufacturers' engineering information for standard catalog units were used to develop the design presented in this appendix. Pump sizing and layout are based on the efficient operation of the station and ease of normal maintenance.

General. One pumping station containing two submersible propeller type pumps is proposed for the Andalusia Refuge. The pumping station will serve a dual function; discharging interior drainage from the protected area to maintain constant water surface elevation during the drawdown cycle; to discharge river water into the protected refuge during the waterfowl migration seasons for the purpose of creating as large a surface area as possible.

The pumping station will be located on the downstream end of the moist soil unit protected from the main channel of the river and associated debris. The pumping station will be constructed integral with the levee river toe section. The levee fill will be placed, allowed to naturally consolidate for approximately three months and then excavated for the pumping station.

Pump units are sized to complete the drawdown period within a two week period. Pump operation will utilize automatic controls for setting and maintaining water elevation within the moist soil unit. The power and control panels will be housed within the pumping station super-structure and will be protected from condensation damage with unit heaters.

Pump and motor removal can be accomplished through secured sealed manhole accesses exterior of the pump station super-structure. Hand-cleaned trash racks are provided at both intake and discharge ends for maximum protection of the pump impellers against debris. The superstructure will have gravity ventilators and louvers for air circulation. Design of the station is based on the Hydraulic Institute Standards, 13th Edition, 1975, and on applicable sections of EM 1110-2-3102, 03, and 05.

Station Features. This station is fed by a new 48-inch reinforced concrete pipe from the moist soil unit passing through the levee section and by a pump forebay section from the Mississippi River. A sump divider wall separates the two pumps up to elevation 551.0. A slide gate in the divider wall permits gravity flow between the moist soil unit and the Mississippi River. Stoplog slots will be provided at each end to facilitate sump dewatering for maintenance purposes. Gate closure of the gravity outlet occurs for water management operation, at which time the required pump is energized manually, with further control being automatic through the float system. One 24-inch, 5,000 gpm submersible pump of axial or mixed flow type will be utilized for pumping from the moist soil unit and one 24 inch 3500 gpm submersible pump of axial or mixed flow type will be utilized for pumping from the Mississippi River. Discharge of both pumps will be piped over the sump divider wall into a stilling basin that directs flow by gravity out to the river or moist soil unit respectively. Access to the sump area will be by ladder through removable floor hatches at the operating floor level. System head computations and curves and example pump selections are shown on plates F-1 through F-11. The estimated operating energy cost of $1200 per year is computed on Plate F-18.

Control Sequence. The sluice gate of the pump station should be operated in an open position except during periods of moist soil unit management by Illinois Department of Conservation personnel. During desired drawdown periods, the sluice gate should be closed and the pump station activated for drawdown purposes. The pump station must be manually activated but will automatically turn off at low water level of 542.0. The float control system will automatically turn the pump on at elevation 542.5 to maintain the 542.0 drawdown elevation.

When it is desired to pump from the river into the moist soil unit, the station must be manually activated and will continue pumping automatically until elevation 547 (which can be adjustable to elevation 550.8, the elevation of the levee overflow). Pumping will be at a slower rate of approximately 3500 gpm to permit a slow filling of the moist soil unit.

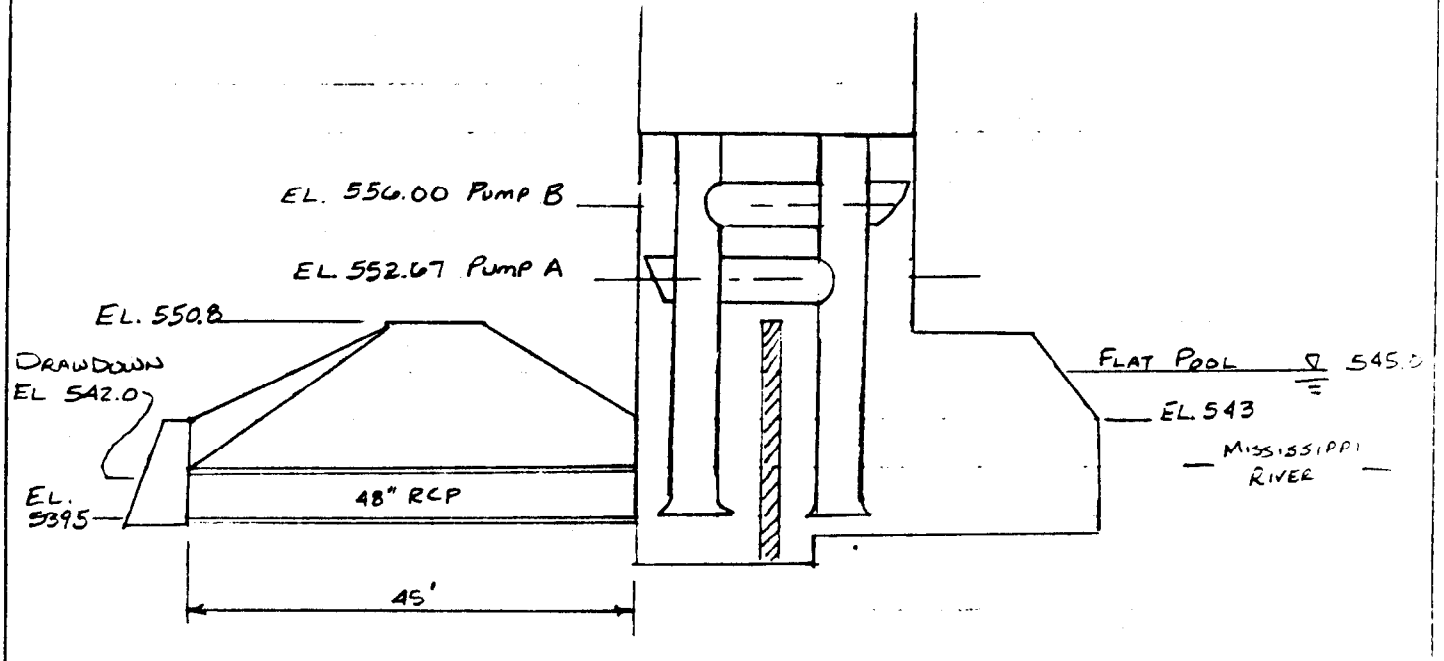
Electrical. The two submersible pumps at the station will be operated with electric motors. Power will be provided by the Iowa-Illinois Gas and Electric Company of Davenport, Iowa. Iowa-Illinois Gas and Electric Company has fossil and nuclear generating plants, is interconnected with many other utilities, and is considered to be a very reliable source of power. Two high voltage power systems are available within the area, 13 KV, 3 phase and 7.6 KV single phase. The nearest 13.2 KV, 3 phase connection point is at the switchgear in Illinois City, Illinois, thereby requiring construction of 3-4 miles of new power line. The 7.6 KV, single phase line can be tapped within one-half mile of the site bringing to conclusion that power to the pump station be tapped from the 7.6 KV line, transformed down with a 37.5 KVA

transformer to 480 volt and converted to 3-phase, 480 volts using a power phase converter located at the pump station location. The high voltage line will span the ± 150 feet of levee from high ground to the east wall of the pump station. The transformer and power phase converter will be mounted on the pumping station roof. Local ownership of the power service will be on the low voltage side of the transformer near the pump station. The Government, through its contractor, will pay for connection charges including powerline, transformers and power converters, and the Iowa-Illinois Gas and Electric Company will own and maintain the high voltage service.

The pumping station will have pump motor loads of approximately 8 KW and 18 KW and motors of 10 hp and 25 hp, one motor of about 3 hp to operate the sluice gate, and a circuit for one motor of about 3/4 hp for the sump pump. A power control panel will be located within the pump superstructure, will house a 480/240/120 volt transformer for lighting, receptacle and the control circuitry.

Short circuit analysis for the station is shown on plates F-12 through F-17. Electrical schematics are shown on plate 22.

Subject		Date
ANDALUSIA REFUGE PUMP STATION		JULY 88
Computed by: WGH	Checked by: DJH	Sheet 1 of

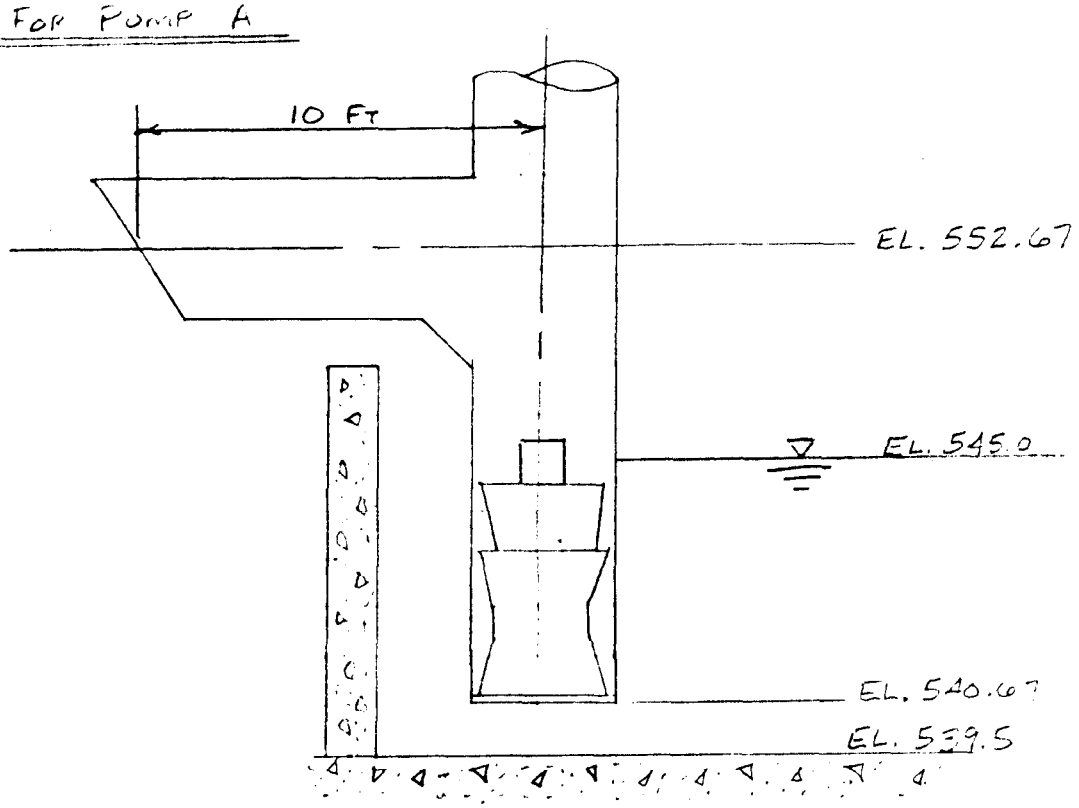


GENERAL CONDITIONS

1. PUMP STATION IS INTEGRAL PART OF RIVERSIDE LEVEE TOE
2. PUMP A PUMPS FROM RIVER TO REFUGE WITH FREE PIPE END DISCHARGE
3. PUMP B PUMPS FROM REFUGE TO RIVER WITH FREE PIPE END DISCHARGE
4. REQUIRED PUMPING RATES
   PUMP A = 3500 gpm max
   PUMP B = 5000 gpm min.
5. FLAT POOL EL. 545.0
   REFUGE MAX POND EL = 550.8
   REFUGE MIN POND EL. = 542.0
   SUMP FLOOR EL. = 539.5

Subject		Date
ANDALUSIA REFUGE PUMP STATION		JULY 83
Computed by: WGH	Checked by: DJH	Sheet 2 of

DESIGN FOR PUMP A



PARAMETERS:

Q_{MAX} = 3500 gpm

H_{STATIC} = 552.67 - 545.0 = 7.67 FT

SUBMERSIBLE PUMP WITH 26" Ø STEEL PIPING

COMPUTE SYSTEM HEAD LOSSES:

PIPE HEAD LOSSES ARE INCLUDED INTO PUMP CURVES UP TO 20 INCHES ABOVE UNIT. ASSUME UNIT HEIGHT EQUAL 50 INCHES.

Subject		Date
ANDALUSIA REFUGE PUMP STATION		JULY 85
Computed by: WGH	Checked by: DJH	Sheet: 3 of

PIPE FLOW VELOCITY = $\left(3500 \frac{GAL}{MIN}\right)\left(\frac{FT^3}{7.48\ GAL}\right)\left(\frac{4}{\pi (2.167\ FT)^2}\right)\left(\frac{MIN}{60\ SEC}\right)$

= 2.115 FT/SEC

$HEAD_{VEL.} = \frac{V^2}{2g} = \frac{(2.115\ FT/S)^2}{2(32.2\ FT/S^2)}$ = 0.069 FT.

SYSTEM COMPONENTS:

PIPE LOSS ~ 0.3 H_V/100 FT

PIPE LENGTH = $(552.67 - 540.67) - \frac{70\ IN}{12\ IN/FT}$ + 10 FT = 16.17 FT

ONE ELBOW ~ 0.33 H_V

EXIT LOSS ~ 1.0 H_V

TRASHRACK LOSS ~ 0.1 H_V

INLET SUMP LOSS ~ 0.1 H_V

TOTAL LOSS = $0.069\left(0.3\left(\frac{16.17}{100}\right) + 0.33 + 1.0 + 0.1 + 0.1\right)$

= 0.109 FT.

TOTAL DYNAMIC HEAD = 7.67 FT + 0.109 FT = 7.78 FT.

PUMP SELECTION:

FLYGT - 7050, 20 KW, 700 RPM, 4 BLADE,
5° BLADE ANGLE, CURVE 63-700E4

Q = 3500 GPM @ 7.8 FT WITH EFF = 70%

CHECK MAXIMUM RECOMMENDED PUMP SPEED IN ACCORDANCE WITH HYDRAULIC INSTITUTE STANDARDS & FIG 60

$N = \frac{N_S H^{3/4}}{\sqrt{Q}} = \frac{20{,}000\ (8)^{0.75}}{\sqrt{3500}}$

N = 1608 RPM > 700 RPM O.K.

NCR Form
1 Aug 80 381b

PLATE F-3

PERFORMANCE CURVE

PROD.	7050
CURVE NO	63-700B4

FREQ	NOMINAL HYDRAULIC-END SPEED
60 HZ	700 RPM

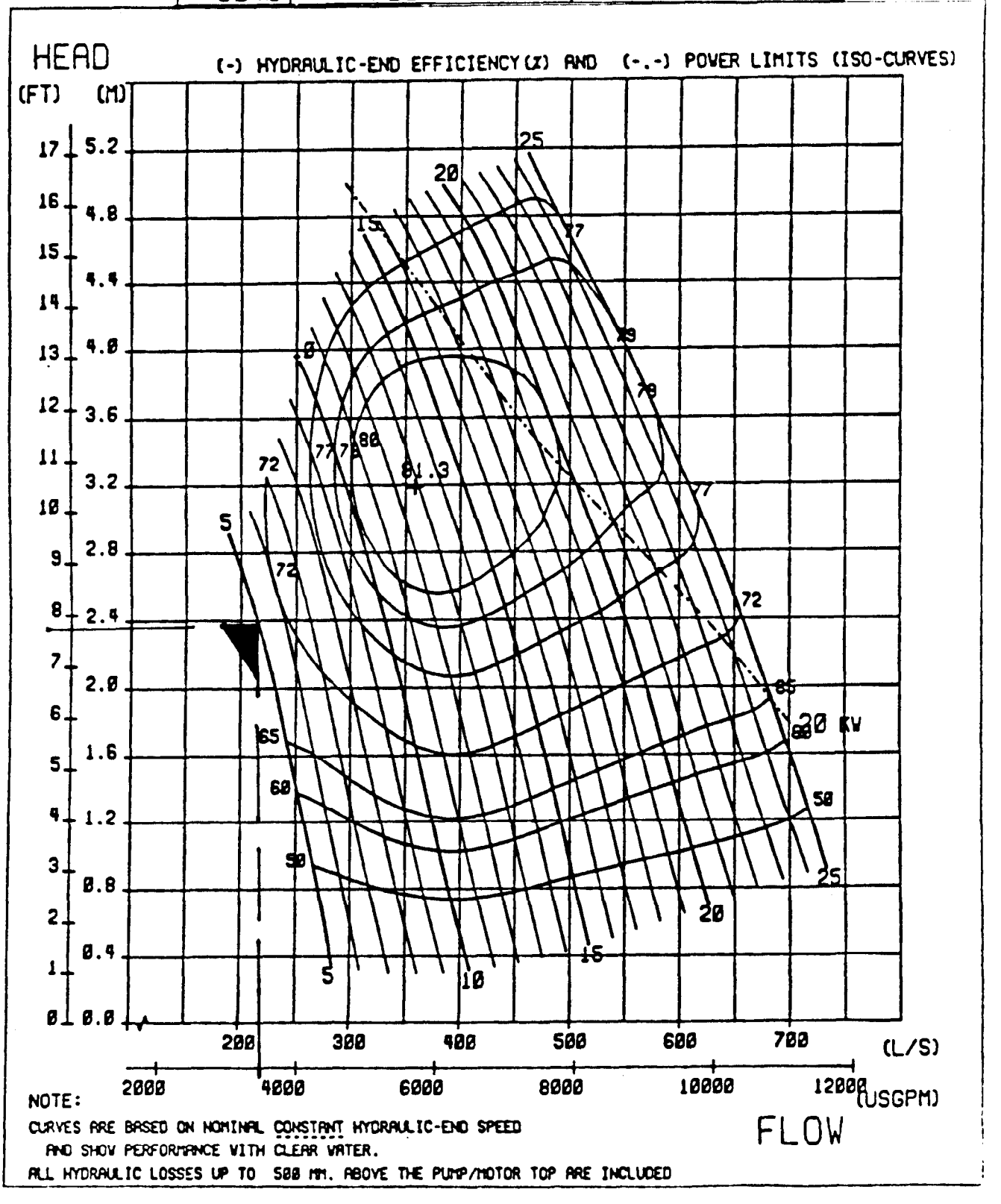
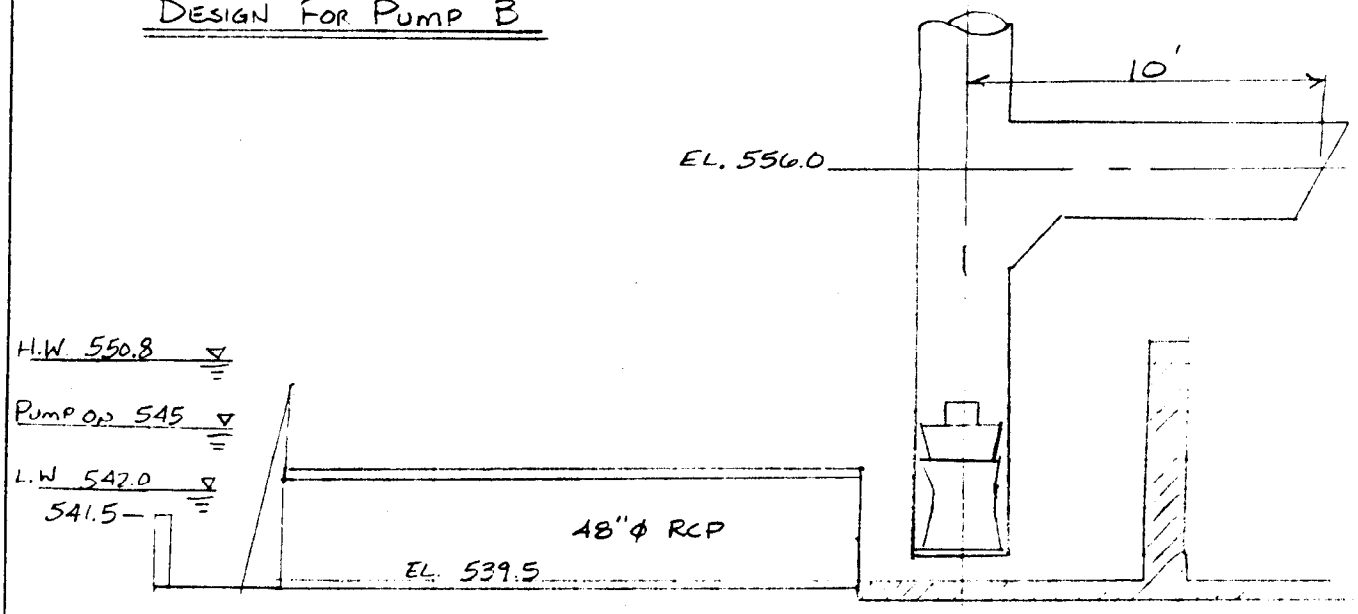


PLATE F-4

Subject		Date
ANDALUSIA REFUGE PUMP STATION		JULY 89
Computed by: WGH	Checked by: DJH	Sheet 5 of

DESIGN FOR PUMP B



PARAMETERS:

Q_{MIN} = 5,000 GPM = 11.14 cfs

$H_{STATIC\ MIN}$ = 556.0 - 545.0 = 11.0 FT.

$H_{STATIC\ MAX}$ = 556.0 - 542.0 = 14.0 FT.

SUBMERSIBLE PUMP WITH 26" ϕ STEEL PIPING

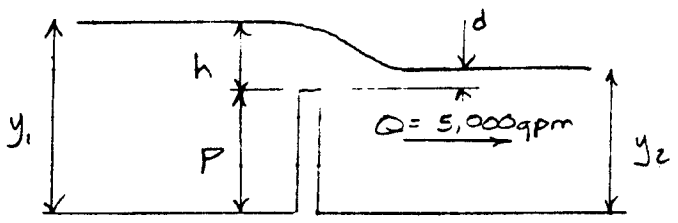
COMPUTE SYSTEM HEAD LOSSES:

LOSSES TO BE CONSIDERED

a) WEIR LOSSES
b) TRASHRACK LOSSES
c) RCP FRICTION LOSSES
d) INLET SUMP LOSSES
e) PUMP PIPE LOSSES
f) PUMP ELBOW LOSSES
g) EXIT LOSS

Subject		Date
ANDALUSIA REFUGE PUMP STATION		JULY 88
Computed by: WGH	Checked by: DJH	Sheet 6 of

a) WEIR LOSSES



CASE 1: WATER ELEVATION = 545 y_1 = 5.5 FT.
WEIR HEIGHT P = 1.75 FT.
CREST HEIGHT = h_1 = 3.75 FT

USING EM 1110-2-5027, 30 SEPT 87 pg. 4-21

$$h = \left[0.3 \frac{Q}{L}\right]^{2/3}$$

SOLVING FOR Q_1

$$Q_1 = (3.75)^{1.5}\left(\frac{14\ FT}{0.3}\right) = 338.9\ cfs = 152,092\ gpm$$

USING HANDBOOK OF APPLIED HYDRAULICS, 3rd ed, DAVIS & SORENSEN

$$\frac{Q}{Q_1} = \left[1-\left(\frac{d}{h}\right)^{1.5}\right]^{0.385}$$

SOLVING FOR d

$$d = \left[1-\left(\frac{5,000}{152,092}\right)^{1/.385}\right]^{2/3} 3.75 = 3.749$$

$$h_L = h - d = 3.75 - 3.749 = 0.001\ FT.$$

CASE 2: WATER ELEVATION = 542
WEIR HEIGHT = P = 1.75 FT.
CREST HEIGHT = h = 0.75

$$Q = (0.75)^{1.5}\left(\frac{14\ Ft}{0.3}\right) = 30.31\ cfs = 13{,}603\ gpm$$

$$d = \left[1-\left(\frac{5{,}000}{13{,}603}\right)^{1/.385}\right]^{2/3} 0.75 = 0.712\ FT$$

$$h_L = h-d = 0.75 - 0.712 = \underline{0.038\ FT.}$$

b. TRASHRACK LOSSES

CONTROLING CASE IS WHEN REFUGE = EL. 542.0

ELEVATION ENTERING TRASHRACK = 542 - 0.25 = EL. 541.75

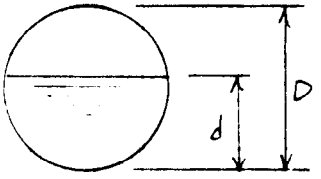
$$V_{T.R} = \frac{11.14\ Ft^3/s}{(6\ Ft)(541.75-539.5\ Ft)} = 0.825\ Ft/s$$

$$\frac{V^2}{2g} = \frac{(0.825\ Ft/s)^2}{64.4\ Ft/s^2} = 0.011\ Ft$$

$$H_{L\,T.R} \doteq 0.1\,\frac{V^2}{2g} = 0.001\ FT.$$

Subject		Date
ANDALUSIA REFUGE PUMP STATION		JULY 88
Computed by: WGH	Checked by: DJH	Sheet: 8 of

C. REINFORCED FRICTION LOSSES



D = 4 FT
d = 541.75 - 539.5 = 2.25 FT
Q = 5,000 gpm
L = 45 FT.

Check for critical depth . REF. EM1110-2-1602, PLATE II

FOR Q = 11.14 cfs, D = 4 FT

$y_c/D = 0.345$

$y_c = 0.345(4') = 1.38$ FT.

SINCE $y_c < d$, SUBCRITICAL FLOW O.K.

Check AREA REF. - U.S. DEPT OF INTERIOR BUREAU OF RECLAIMATION - HYDRAULIC & EXCAVATION TABLES

AT y_c

FOR $\frac{d}{D} = \frac{2.25}{4} = 0.563$

$Q = 1.7505(4)^{2.5} = 56.018$ cfs

$h_v = 0.2296(4) = 0.9184$ FT $\therefore$ V = 7.6906 fps

AND $A = \frac{Q}{V} = \frac{56.018}{7.6906} = 7.28$ FT^2

COMPUTE VELOCITY ACTUAL

$V = \frac{Q}{A} = \frac{11.14}{7.28} = 1.53$ fps

WETTED PERIMETER = $R\left[\pi + \frac{2}{180}\left(\sin^{-1}\frac{.25}{2}\right)\pi\right] = 1.0798\,\pi R$

Subject		Date
ANDALUSIA REFUGE PUMP STATION		JULY 88
Computed by: WGH	Checked by: DJH	Sheet 9 of

COMPUTE HYDRAULIC RADIUS

$$R = \frac{\text{AREA}}{\text{W. PERIMETER}}$$

$$R = \frac{7.28\ FT^2}{1.0798\,\pi\,(2\ FT)} = 1.073\ FT$$

USING MANNING EQUATION

$n = 0.013$ FOR CONCRETE PIPE

$$H_L = S = \left(\frac{nV}{1.49\,R^{2/3}}\right)^2 (45\ FT)$$

$$H_{L\,pipe} = \left[\frac{0.013\,(1.53\ fps)}{1.49\,(1.073\ FT)^{2/3}}\right]^2 (45\ FT)$$

$$H_{L\,pipe} = 0.007\ FT.$$

d, e, f, g) COMPUTE PUMP ASSOCIATED LOSSES

$$\text{PUMP PIPE VELOCITY} = (11.14\ \tfrac{FT}{S})\left(\frac{4}{\pi\,(2.167\ FT)^2}\right) = 3.02\ \tfrac{FT}{S}$$

$$H_{VEL} = \frac{V^2}{2g} = \frac{(3.02)^2}{2(32.2)} = 0.142\ FT.$$

PIPE LOSS ~ $0.3\ H_V / 100\ FT$
ELBOW ~ $0.33\ H_V$
EXIT ~ $1.0\ H_V$
INLET SUMP ~ $0.2\ H_V$

Subject		Date
ANDALUSIA REFUGE PUMP STATION		JULY 8?
Computed by: WGH	Checked by: DJH	Sheet 10 of

PIPE LENGTH = $556 - 540.67 - \frac{70}{12} + 10\ FT = 19.50\ FT$

$$H_{L\,pump} = 0.142\left(0.3\left(\frac{19.5}{100}\right) + 0.33 + 1.0 + 0.2\right)$$

$$H_{L\,pump} = 0.225\ FT$$

COMPUTE SYSTEM LOSS

$$H_{L\,SYST.} = H_{L\,weir} + H_{L\,T.R.} + H_{L\,pipe} + H_{L\,pump}$$

$$H_{L\,SYST.} = 0.038\ FT + 0.001\ FT + 0.007\ FT + 0.225\ FT$$

$$H_{L\,SYSTEM} = 0.272\ FT.$$

PUMP TDH = $14 + 0.272 = 14.272\ FT.$

PUMP SELECTION:

FLYGT - 7050, 20 KW, 700 RPM, 4 BLADE,
13° BLADE ANGLE, CURVE 03-7005.4
Q = 5,000 gpm @ 14.2 FT. @ 77.9% eff.

CHECK MAXIMUM RECOMMENDED PUMP SPEED

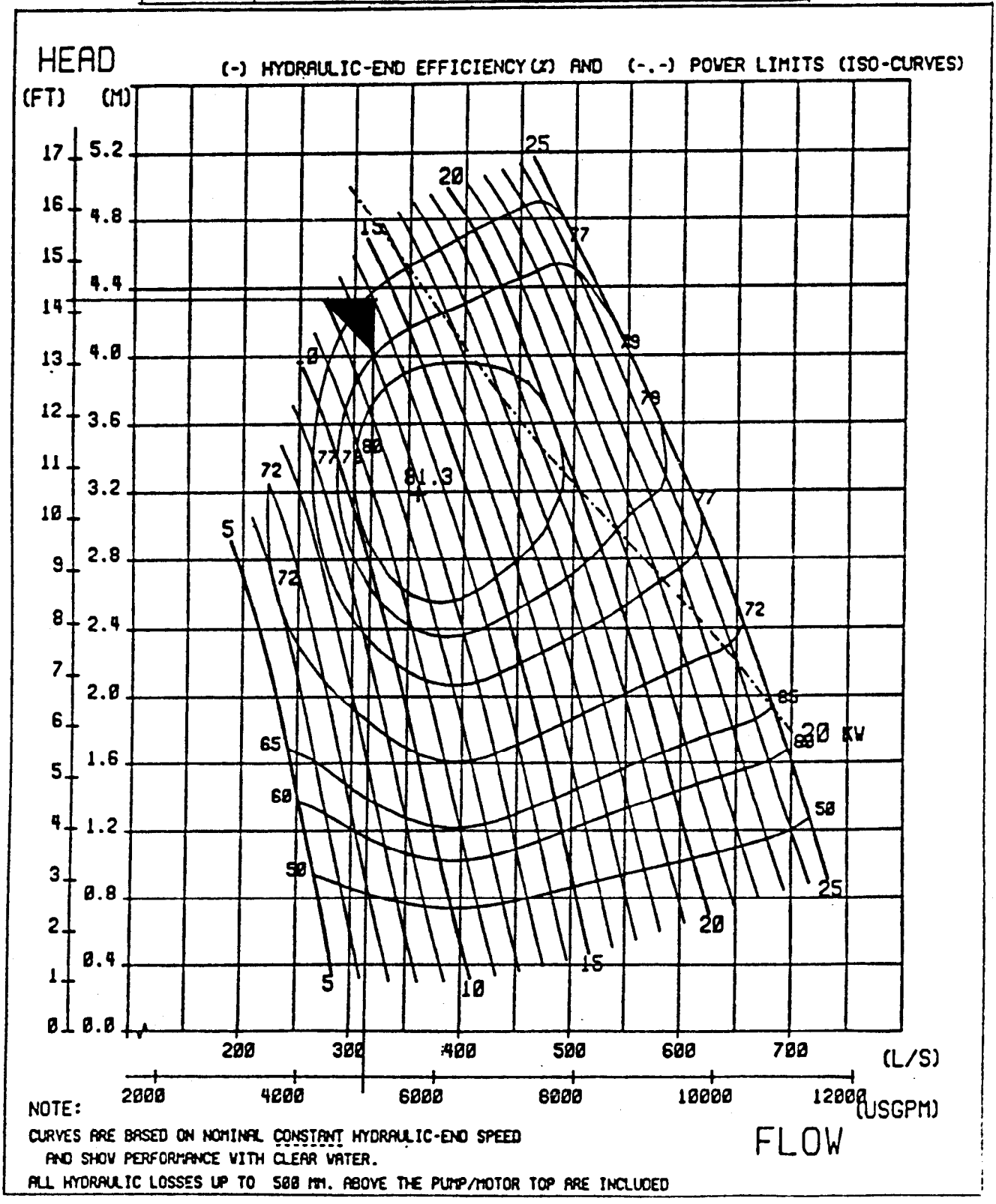
$$N = \frac{N_S H^{3/4}}{\sqrt{Q}} = \frac{15{,}000\,(14.3FT)^{0.75}}{\sqrt{5{,}000}}$$

$N = 1{,}560$ RPM > 700 RPM O.K.

PERFORMANCE CURVE

PROD.	CURVE NO
7050	63-700B4

FREQ	NOMINAL HYDRAULIC-END SPEED
60 HZ	700 RPM



NOTE:
CURVES ARE BASED ON NOMINAL CONSTANT HYDRAULIC-END SPEED AND SHOW PERFORMANCE WITH CLEAR WATER.
ALL HYDRAULIC LOSSES UP TO 500 MM. ABOVE THE PUMP/MOTOR TOP ARE INCLUDED

PLATE F-11

Subject		Date
ANDALUSIA REFUGE PUMP STATION		JULY 88
Computed by: WGH	Checked by: DJH	Sheet 12 of

LOAD STUDY

EXISTING POWER SYSTEM - HIGH VOLTAGE 7620 VOLT, 1 ϕ
POWER STATION SYSTEM - SECONDARY VOLTAGE 480/277/ 3 ϕ

SUBMERSIBLE PUMP LOAD REQUIREMENTS

PUMP A = 7.4 KW = 10 H.P.
PUMP B = 17.4 KW = 25 H.P.

ASSUME ONLY ONE WILL BE PUMPING AT ANY GIVEN TIME

$$I_L = \frac{17.4(1000)}{480\sqrt{3}(.95)} = 22.0 \text{ AMP}$$

GIVEN a 25 HP MOTOR ON THE PUMP

I_L = 34 AMP NEC TABLE 430-150

SIZE BRANCH CIRCUIT CONDUCTOR FOR PUMP B NEC TABLE 310-16

$I_{FL} = (34)(1.25) = 42.5$ AMP SELECT # 8 I = 50

SIZE BRANCH CIRCUIT CONDUCTOR FOR PUMP A (10 H.P.)

$I_{FL} = (14 A)(1.25) = 17.5$ amp SELECT # 12 I = 25

POWER REQUIREMENT FOR PUMP B

$(746)(25 HP)(1.25) = 23.3$ KVA

Subject		Date
ANDALUSIA REFUGE PUMP STATION		JULY 83
Computed by: WGH	Checked by: DJH	Sheet 13 of

SUMP PUMP LOAD REQUIREMENTS

3/4 H.P. CLASS G, 240 V, 1Φ, 60 Hz, 1800 RPM

$$I_L = \frac{(0.75\,HP)(1000)}{(240\,V)(0.65)} = 4.8\,A$$

USING NEC TABLE 430-148 $I_L = 6.9$ A

SIZE BRANCH CIRCUIT CONDUCTOR FOR SUMP PUMP

$I_{FL} = (6.9\,A)(1.25) = 8.65\,A$ SELECT #12 AWG

POWER REQUIREMENT FOR SUMP PUMP

$(746)(0.75\,HP)(1.25) = 0.70$ KVA

SLUICE GATE LOAD REQUIREMENTS

ASSUME

3 H.P. CLASS S, 3Φ, 480 V, 60 Hz, 1200 RPM

$$I_L = \frac{(3\,HP)(1000)}{(480)\sqrt{3}\,(.75)} = 4.8\,A$$

USING NEC TABLE 430-150 $I_L = 4.8$ A

SIZE BRANCH CIRCUIT CONDUCTOR FOR SLUICE GATE

$I_{FL} = (4.8\,A)(1.25) = 6.0\,A$ SELECT #12 AWG

POWER REQUIREMENT

$(746)(3\,HP)(1.25) = 2.8$ KVA

Subject		Date
ANDALUSIA REFUGE PUMP STATION		JULY 93
Computed by: WGH	Checked by: DJH	Sheet 14 of

DETERMINE TRANSFORMER SIZE

$LOAD_{MAX}$ = 23.3 KVA + 0.7 KVA + 2.8 KVA = 26.8 KVA

CHOOSE A 37.5 KVA, 1ϕ

DETERMINE SIZE OF MAIN BREAKER OF FUSE

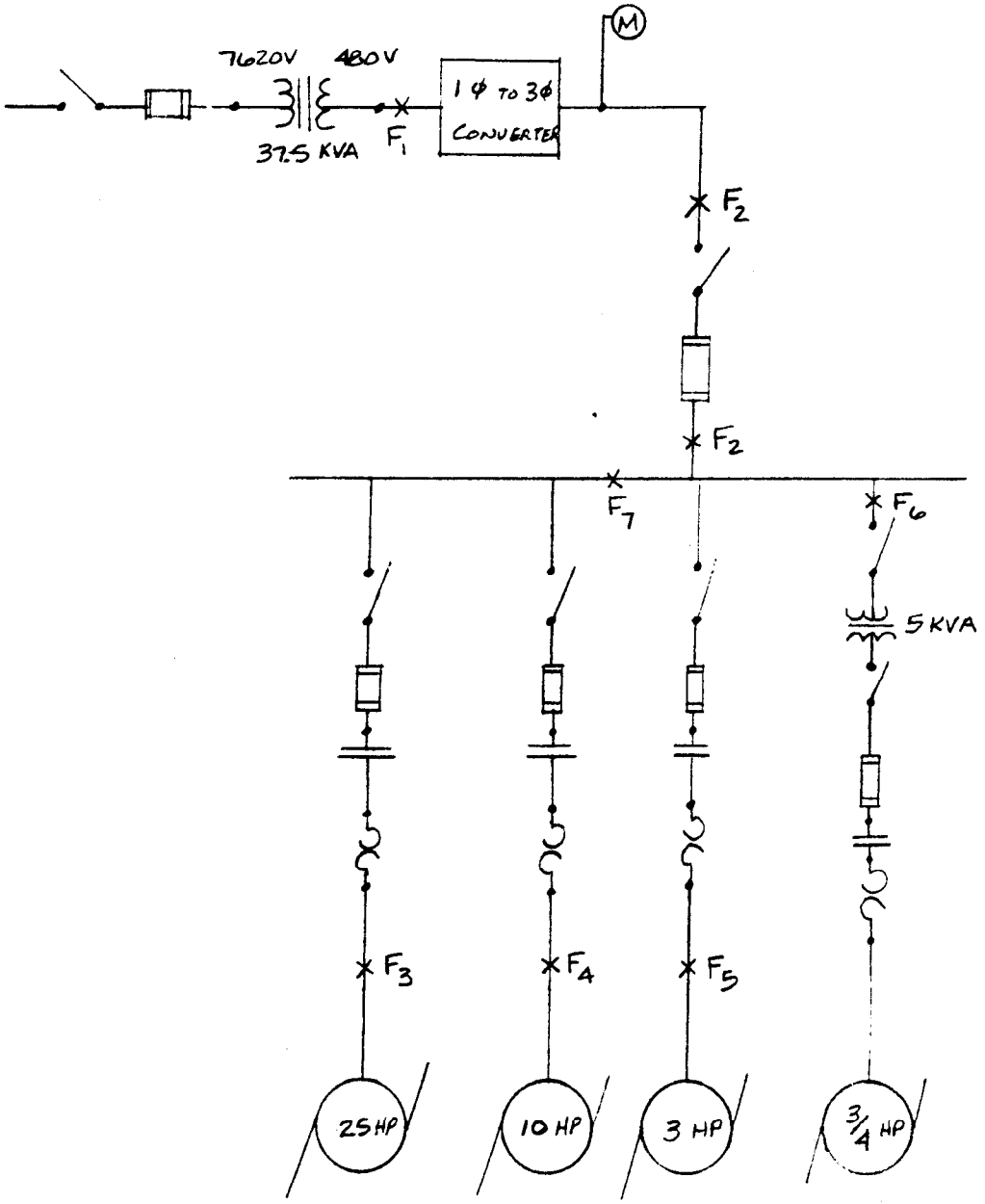
$$I = 2.5(34\ AMP) + \frac{4.8\ A}{2\sqrt{3}} + 4.8\ A$$

I = 92 AMP

CHOOSE 150 A BUS
100 A BREAKER
3 - #3 AWG MAIN FEEDER WITH #6 AWG GRD.

Subject		Date
ANDALUSIA REFUGE PUMP STATION		JULY 85
Computed by: WGH	Checked by: DJH	Sheet 15 of

FAULT STUDY



Subject		Date
ANDALUSIA REFUGE PUMP STATION		JULY 89
Computed by: WGH	Checked by: DJH	Sheet 16 of

SYSTEM BASE - 500 MVA

PUMP B FEEDER - 3-#8 AWG

$C = 1230$

$R = 0.778$ ohm / FT $\times 10^3$

PUMP A FEEDER - 3 # 12 AWG

$C = 617$

$R = 1.98$ ohm / FT $\times 10^3$

SUMP & SLUICE FEEDER - 3 # 12 AWG

$C = 617$

$R = 1.98$ ohm / FT $\times 10^3$

BUS FEEDER - 3 # 3 AWG

$C = 3830$

$R = 0.245$ ohm / FT $\times 10^3$

Z TRANSFORMER = 2 %

AT F_1

$$I_{sc} = \frac{(37.5\,KVA)(1000)}{480\,(0.02)} = 3906 \text{ AMP}$$ AT TRANSFORMER SECONDARY

AT F_2

$$f = \frac{1.73\,L\,I}{C\,V} = \frac{1.73(50)(3906\,A)}{3830(480)} = 0.1838$$

$$I_{F_2} = 3906\left(\frac{1}{1+0.1838}\right) = 3300 \text{ AMP}$$

AT F_3

$$f = \frac{1.73(20)(3300\,A)}{(480)/1230)} = 0.1934$$

$$I_{F_3} = 3300\left(\frac{1}{1+0.1934}\right) = 2765 \text{ AMP}$$

Subject		Date
ANDALUSIA REFUGE PUMP STATION		JULY 88
Computed by: WGH	Checked by: DJH	Sheet 17 of

AT F_4 $\quad f = \frac{1.73(20)(3300A)}{(480V)(617)} = 0.3855$

$$I_{F_4} = 3300\left(\frac{1}{1+0.3855}\right) = 2382 \text{ AMP}$$

AT F_5 $\quad f = \frac{1.73(20)(3300A)}{(480V)(617)} = 0.3855$

$$I_{F_5} = 3300\left(\frac{1}{1+0.3855}\right) = 2382 \text{ AMP}$$

AT F_6 $\quad f = \frac{2(10FT)(3300)}{480(617)} = 0.2229$

$$I_{F_6} = 3300\left(\frac{1}{1+0.2229}\right) = 2700 \text{ AMP}$$

CONCLUSIONS: ALL EQUIPMENT SHALL BE RATED FOR 10,000 AMP RI

Subject		Date
ANDALUSIA REFUGE PUMP STATION		JULY 88
Computed by: WGH	Checked by: DJH	Sheet 18 of

PUMP STATION OPERATING ENERGY COST

DRAINAGE AREA = 925 ACRE

STATION CAPACITY PUMP A = 3500 GPM ≐ 15.75 ACRE FT/DAY

STATION CAPACITY PUMP B = 5,000 GPM ≐ 22.5 ACRE FT/DAY

TIME PERIOD	OPERATION	PUMP	INITIAL VOL. ACRE-FT	RAINFALL (IN)	RUNOFF C=.5 (ACRE FT)	EVAPOR. (ACRE-FT)	EVENT VOL. (ACRE-FT)	TOTAL (A-FT
JUNE	DRAWDOWN	B	42	4.32	166.5	- 16.8	2.1 *	193.8
JULY	DRAWDOWN	B	0	4.88	188.1	- 17.5	2.1 *	172.7
AUG	DRAWDOWN	B	0	3.76	144.9	- 14.9	2.1 *	132.
							SUBTOTAL	498.6
SEPT	FILL	A	180	3.74	- 288.3	38.5		0
OCT	FILL	A	0	2.70	- 208.0	38.5		0
NOV	FILL	A	0	2.16	- 166.5	38.5		0
							SUBTOTAL	0

* VOLUME IS BASED ON DURATION OF EVENT CAUSING OVERFLOWING EL. 550.0 REQUIRING A SECOND DRAWDOWN - (5%)(42) = 2.1 ACRE FT.

$$\text{PUMP B RUN. TIME} = \left(498.6 \frac{\text{ACRE-FT}}{\text{YR}}\right)\left(\frac{\text{DAY}}{22.5 \text{ ACRE-FT}}\right) = 22.16 \frac{\text{DAY}}{\text{YR}} = 532 \frac{\text{HR}}{\text{YR}}$$

$$\text{PUMP A RUN TIME} = \left(0 \frac{\text{ACRE-FT}}{\text{YR}}\right)\left(\frac{\text{DAY}}{15.75 \text{ ACRE-FT}}\right) = 0 \frac{\text{DAY}}{\text{YR}} = 0 \frac{\text{HR}}{\text{YR}}$$

POWER REQUIREMENT - ASSUME 5 HR RUN TIME FOR MAINTENANCE & TESTING/YR

$$P_{\text{pump}} = \left(17.4 \text{ KW}\right)\left(532 + 5 \frac{\text{HR}}{\text{YR}}\right) + \left(7.4 \text{ KW}\right)\left(0 + 5 \frac{\text{HR}}{\text{YR}}\right) = 9{,}378 \text{ KWH/YR}$$

$$P_{\text{heaters \& controls}} = (0.3 \text{ KW})\left(24 \frac{\text{HR}}{\text{DAY}}\right)\left(365 \frac{\text{DAY}}{\text{YR}}\right) = 2{,}628 \text{ KWH/YR}$$

$$\text{AVERAGE OPERATING COST} = \left(9{,}378 + 2{,}628 \frac{\text{KWH}}{\text{YR}}\right)(\$0.093/\text{KWH})$$

OPERATING COST = $1,117.00/YR. SAY $1200/YR

NCR Form 1 Aug 80 381b

PLATE F-18

APPENDIX G

SEDIMENTATION STUDY

UPPER MISSISSIPPI RIVER SYSTEM
ENVIRONMENTAL MANAGEMENT PROGRAM
DEFINITE PROJECT REPORT (R-4)

ANDALUSIA REFUGE REHABILITATION AND ENHANCEMENT
POOL 16 MISSISSIPPI RIVER MILES 462 TO 463
ROCK ISLAND COUNTY, ILLINOIS

APPENDIX G
SEDIMENTATION STUDY

A sedimentation study was conducted to evaluate sedimentation in Dead Slough and in the Refuge area during the period 1936 through 1987. The scope of this study, as presented in this appendix, consisted of determining net erosion from 1936 (pre-lock and dam) through 1987, estimating annual adjacent watershed erosion/deposition, evaluating estimated river source sedimentation, and evaluating proposed project impacts on sedimentation.

Baseline elevations were established from 1936 plane table topographic maps. Additional sections were taken by survey crews during 1987. Eleven ranges were used to construct cross sections of this area. Elevations in 1936 were compared with present elevations in 1987 to show net changes in elevation. Table G-1 provides a summary of net sedimentation.

The two predominant sedimentation sources are the Mississippi River and upland erosion. Adjacent watersheds were studied to estimate approximate soil loss from these areas. Estimates were derived from the Universal Soil Loss Equation, reference: Predicting Rainfall Erosion Losses, USDA, Handbook Number 537, December 1978. Estimated adjacent watershed erosion is presented in table G-2.

TABLE G-1

Andalusia Refuge and Dead Slough Total Sedimentation

Range	Station	Total Sediment Deposition in Andalusia Refuge & Dead Slough 1936-1987: Average Depth, Ft	Total Sediment Deposition in Andalusia Refuge & Dead Slough 1936-1987: Average Annual Depth, In/Yr	Dead Slough Sediment Deposition, 1936-1987 Below Elevation 545.0 (Flat Pool): Average Depth, Ft	Dead Slough Sediment Deposition, 1936-1987 Below Elevation 545.0 (Flat Pool): Annual Average In/Yr
A	15+15	2.1	0.49	2.9	0.68
B	23+75	2.3	0.54	3.8	0.90
C	30+75	2.5	0.58	2.7	0.63
D	38+25	1.7	0.40	3.9	0.91
E	45+75	1.7	0.40	4.2	1.00
F	2+75.15CE	2.2	0.53	-	-
G	4+55.62CE	2.3	0.54	-	-
H	8+88.12CE	2.4	0.56	-	-
I	12+70CE	2.5	0.58	-	-
J	16+16.26CE	2.2	0.52	-	-
K	20+75CE	2.2	0.52	-	-
OVERALL		2.2	0.52		0.82 in/yr

TABLE G-2

Estimated Sediment from Adjacent Watersheds

Watershed	Area, Ac	Watershed Gross Erosion: T/Ac/Yr	Watershed Gross Erosion: T/Yr	Watershed Gross Erosion: Ac-Ft/Yr	Delivery Ratio 1/	Sediment Yield 2/: T/Yr	Sediment Yield 2/: Ac-Ft/Yr
A	519	13	6,800	3.9	.55	3,700	2.2
B	774	16	12,000	6.9	.55	6,600	3.8
C	208	10	2,100	1.2	.65	1,400	0.8
D	1,152	13	15,000	8.6	.48	7,200	4.2
Total	2,653	-	35,900	20.6	-	18,900	11.0

1 Reference: "Sediment Delivery Ratios vs. Drainage Area," USDA, Soil Conservation Service, drawing number 5, N-30,509, dated October 1970.

2 Sediment Yield = Gross Erosion x Delivery Ratio. Sediment yield is the portion of the gross watershed erosion that actually reaches the watershed mouth.

Net river sedimentation was estimated by subtracting the adjacent watershed sedimentation (table G-2) from the net sedimentation (table G-1). Results of this comparison and potential reductions in sedimentation due to proposed project features are presented in table G-3.

TABLE G-3

Comparison of River Versus Upland Erosion Sedimentation

Sedimentation Source	Existing Conditions		Sediment Reduction into Andalusia Refuge Due to Proposed Project	
	Ac-Ft/Yr	%	Ac-Ft/Yr	%
Adjacent Watershed	11.0	64.7	4.2	24.7
River	6.0	35.3	0.0	0.0
Net	17.0	100.0	4.2	24.7

ILLINOIS DEPARTMENT OF CONSERVATION
FISHERIES INVESTIGATION OF DEAD SLOUGH

APPENDIX

MISSISSIPPI RIVER
INVESTIGATIONS

County Rock Island
Location from
nearest town 7 mi. West of Andalusia
Date May 16, 1988

Station Sampled Dead Slough/Andalusia Refuge Pool No. or Name 16

Stations Location in River Miles 462.4-463.0

UMRCC Habitat Classification: Tailwater ____ Lake X Pond ____
Main channel ____ Main channel border ____ Side channel ____ Slough X

Time Temp. Rec. 1:40 (AM) PM Temperature: Air ____ °F, Water Surface 13 c °F

Water Color Clear Sky(weather) Cloudy Wind W-15mph

Turbidity: Secchi To bottom = 1.5' : Cause: ____

Chemistry: pH 8.0 Alkalinity 137 Other Cond:580 DO: 11.2

Water Level: Low X Normal ____ High ____ Flood ____

Velocity(ft./sec.) 0 Max. Depth 18" Avg. Depth 12"
Max. Width 100 yds. Min. Width 100 yds. Avg. Width 100 yds.

Bottom types(%): Silt(muck) X Sand ___ Gravel ___ Rubble ___ Boulders ___ Bedrock ___

Type of Shoreline(%): Gravel bar ___ Sandbar ___ Mud flat ___ Rocky ___
Steep Mud bank 100 Other ____

Aquatic Vegetation(% & type): 95% coverage coontail, curlyleaf, duckweed, potamogeton

Fish Habitat available: Brush X Logs X Stumps X Rock dikes ___
Pile dikes ___ Gravel ___ Rip rap ___ Aquatic vegetation ___
Other ____

Recent Angler Success No Access

Fish Population Analysis: Bag Seine Hauls (Size ____, No. ____);
Hoop Net (No. ___ Size ___ Hrs.Set ___); Trap Net (No. ___ Size ___ Hrs. Set ___);
Gill Net (No. ___ Size ___ Hrs. Set ___); Trammel Net(No. ___ Size ___ Hrs. Set ___);
Electro-Fishing (Time 1:30 (AM) PM 45 minutes, effeciency Poor
Toxicant (area treated ____ acres); Other ____

Fish condition: Some fin rot and lerneae, generally poor condition

Fish Diseases: ____

Number of species collected 10 Observed but not collected ____

Pollution ____

Fisherman usage No Access

Time on Job: 4.0 hrs. Personnel Involved Dan Sallee, Ed Walsh
Reported by: Dan Sallee Date of Report 5/16/88

Additional Remarks and Map on Reverse Side:

ILLINOIS DEPARTMENT OF CONSERVATION
DIVISION OF FISHERIES

FISH POPULATION ANALYSIS

(Condition factor & Length-Frequency Summary

COUNTY Rock Island

WATER (NAME) Miss., Dead Sl/Andalusia Ref.

DATE OF COLLECTION 5/16/88

Species	½" Group	Number	Percent of Total	Weight	Condition Factor	Rating
Shortnose gar	553	1	100%	540		
Bowfin	663	1	100%	2300		
Gizzard shad	274	1	12.5	230		
	281	1	12.5	250		
	282	1	12.5	250		
	286	1	12.5	220		
	312	1	12.5	370		
	322	1	12.5	300		
	336	1	12.5	480		
	377	1	12.5	520		
		8	100%			
Central mudminnow		1	(Preserved)			
Carp	114	1	12.5	30		
	157	1	12.5	90		
	171	1	12.5	90		
	173	1	12.5	90		
	177	1	12.5	90		
	233	1	12.5	250		
	477	1	12.5	1180		
	616	1	12.5	2850		
		8	100%			

Sampling Time Involved: 45 min. Method of Collection: Cartop electofishing

Biologist: Dan Sallee Date of Report: 5/16/88

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F.M. 12.0 (8-70)

ILLINOIS DEPARTMENT OF CONSERVATION
DIVISION OF FISHERIES

FISH POPULATION ANALYSIS

(Condition factor & Length-Frequency Summary

COUNTY Rock Island

WATER (NAME) Miss., Dead Sl/Andalusia Ref

DATE OF COLLECTION 5/16/88

Species	½" Group	Number	Percent of Total	Weight	Condition Factor	Rating
Golden shiner	67	1	16.6	- -		
	73	1	16.6	- -		
	88	1	16.6	- -		
	89	1	16.6	- -		
	92	1	16.6	- -		
	95	1	16.6	- -		
		6	100%			
Smallmouth buffalo	132	1	16.6	30		
	138	1	16.6	40		
	145	1	16.6	50		
	147	2	33.3	100		
	165	1	16.6	70		
		6	100%			
Bluegill	65	1	2.5	- -		
	73	1	2.5	- -		
	77	1	2.5	- -		
	78	1	2.5	- -		
	82	1	2.5	- -		
	84	1	2.5	- -		
	93	1	2.5	- -		
	96	1	2.5	20		
	97	1	2.5	20		
	101	1	2.5	20		
	103	1	2.5	20		
	105	1	2.5	20		
	106	1	2.5	25		
		(continued on next page)				

S[illegible]ling Time Involved: 45 min. Method of Collection: Cartop electrofishing

Biologist: Dan Sallee Date of Report: 5/16/88

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F.M. 12.0 (8-70)

ILLINOIS DEPARTMENT OF CONSERVATION
DIVISION OF FISHERIES

FISH POPULATION ANALYSIS

(Condition factor & Length-Frequency Summary

COUNTY Rock Island

WATER (NAME) Miss., Dead Sl/Andalusia ef.

DATE OF COLLECTION 5/16/88

Species	½" Group	Number	Percent of Total	Weight	Condition Factor	Rating
Bluegill (continued)	107	1	2.5	25		
	108	2	5.0	60		
	109	1	2.5	30		
	115	1	2.5	40		
	118	1	2.5	40		
	126	1	2.5	40		
	134	2	5.0	120		
	137	1	2.5	80		
	148	1	2.5	90		
	152	1	2.5	100		
	153	3	7.5	285		
	155	1	2.5	100		
	156	1	2.5	100		
	158	1	2.5	100		
	160	1	2.5	100		
	166	2	5.0	230		
	167	1	2.5	130		
	172	2	5.0	310		
	178	2	5.0	310		
	212	1	2.5	260		
		40	100%			
Largemouth bass	170	1	50.0	60		
	251	1	50.0	280		
		2	100%			

Sampling Time Involved: 45 min. Method of Collection: Cartop electrofishing

Biologist: Dan Sallee Date of Report: 5/16/88

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ILLINOIS DEPARTMENT OF CONSERVATION
DIVISION OF FISHERIES

FISH POPULATION ANALYSIS

(Condition factor & Length-Frequency Summary

COUNTY Rock Island

WATER (NAME) Miss., Dead Sl/Andalusia Ref.

DATE OF COLLECTION 5/16/88

Species	½" Group	Number	Percent of Total	Weight	Condition Factor	Rating
Black crappie	144	1	20.0	40		
	233	1	20.0	200		
	243	1	20.0	240		
	255	1	20.0	250		
	267	1	20.0	300		
		5	100%			

S ing Time Involved: 45 min. Method of Collection: Cartop electrofishing

Biologist: Dan Sallee Date of Report: 5/16/88

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APPENDIX I

WATERFOWL OBSERVATION DATA FOR ANDALUSIA REFUGE

The following waterfowl observation data originates from annual U.S. Fish and Wildlife Service aerial census counts made along the Upper Mississippi River. The records for Andalusia refuge are incomplete since during some counts the refuge area was not separated from other locations in Pool 16. Previous to 1987, Dead Slough was not included in the count since it was not part of the refuge until 1987.

DATE	MALLARD	BLK	PINT	BWT	GWT	WIG	GAD	SHOV	SCAUP	RN	CANS	RH	RUDDY	GLD EYE	BH	COM MER	RB MER	H MER	CG	LE CG	ST CG	BSG	COOT
10-27-87	400	20	80		50	200	80	75	50										40				650
11-2-87	525	15	20		50	80	30	100	200	75	30			5					50				600
11-9-87	400	25				50	30		200	40				30		10			50				200
11-17-87	475	25	60			100			125	40			40	20	35								75
11-23-87	350	15							250	40	30			125	30	40			100				
12-02-87	225	25							325	75	25		75	175	60	50		20	80				
12-16-87	200	15												350		125		15	125				

AERIAL CENSUS DATA — ANDALUSIA REFUGE (INCLUDES DEAD SLOUGH)

DATE	MALLARD	BLK	PINT	BWT	GWT	WIG	GAD	SHOV	SCAUP	RN	CANS	RH	RUDDY	GLD EYE	BH	COM MER	RB MER	H MER	CG	SN CG	GT CG	BSG	COOT	BALD EAGLE
1-5-84	0																							
2-20-84	30													50		15								2
3-5-84	175	15												75		20			25					
3-21-84	500	40							225	75				80		40			50					3
4-11-84		NO	CENSUS																					
9-4-84	40			60																				
9-11-84	125			200	50	50																		
10-29-84	175	10			125	80																	350	
11-5-84	200	10				60			30														150	1
11-12-84	200	20				60																	75	1
11-20-84	80	5							60	30				40		15								2
11-26-84	125	10												15										2
12-3-84	125	15												30		10								2
12-10-84	40																							2

AERIAL CENSUS DATA - ANDALUSIA REFUGE

DATE	MALLARD	BLK	PINT	BWT	GWT	WIG	GAD	SHOV	SCAUP	RN	CANS	RH	RUDDY	GLD EYE	BH	COM MER	RB MER	H MER	CG	SCG	GTCG	BSG	COOT	
10-17-83	35																							
10-25-83	150	10							40														60	
11-1-83	NO		CENSUS - HEAVY					RAIN																
11-8-83	75	10			30				30														25	
11-14-83	200	10				75			50														25	1
11-21-83	100	5																						1
11-29-83	80	10																						1
12-8-83	25													10										1

OFFICIAL CENSUS DATA - ANDALUSIA REFUGE

DATE	MALLARD	BLK	PINT	BWT	GWT	WIG	GAD	SHOV	SCAUP	RN	CANS	RH	RUDDY	GLD EYE	BH	COM MER	RB MER	H MER	CG	SNOW CG	BLUE CG	BSG	COOT	BALD EAGLE
1-3-83	60													25		5								1
3-1-83	225	10							60	30				75		20								2
3-7-83	275	20							350	175	60		40	5					50					4
3-14-83	600	30				50			650	325	80	40		100		30			50				75	
3-22-83	325	20							275	150	50	25		75		30								2
3-28-83	800	30				175			650	275	175	75		40	35	25							100	2
4-4-83	400	30				30			650	275	80	150		25	20	10							500	2
4-11-83	250	10							900	375	150	50	30	125		40							750	1
4-25-83	60					25			125	50			15	30		10							250	
9-6-83	25			60																				
9-13-83	50			80	30																			
9-19-83	80			50																			25	
9-26-83	60			30																			20	
10-3-83	80		25																				30	
10-11-83	35																						30	

ACRIAL CENSUS DATA — ANDALUSIA REFUGE

Date	Mallard	BLK	PINT	BWT	GWT	WIG	GAD	SHOV	SCAUP	RN	CANS	RH	RUDDY	G.D. EYE	BH	COM MER	R.B. MER	H MER	L.G	SM CG	GT CG	BSG	COOT	BALD EAGLE
9-14-82	20			65																			50	
9-21-82	60					25																	40	
9-27-82	50			30		25																	60	
10-4-82	40					15																	40	
10-11-82	75		25			50																	100	
10-18-82	175					80																	75	1
10-26-82	175	5				80		35															75	
11-4-82	NO	CENSUS		DUE	TO	FOG																		
11-8-82	225	5	40			80																	100	
11-15-82	80	25																						1
12-6-82	80								30					10		10								1
12-13-82	200	20		MISS.	RIVER	ABOVE	FLOOD	STAGE						75		25								2

ATTICA CENSUS DATA — ANDALUSIA REFUGE